RESOURCES for the FUTURE

Federal Climate Policy 104: The Transportation Sector

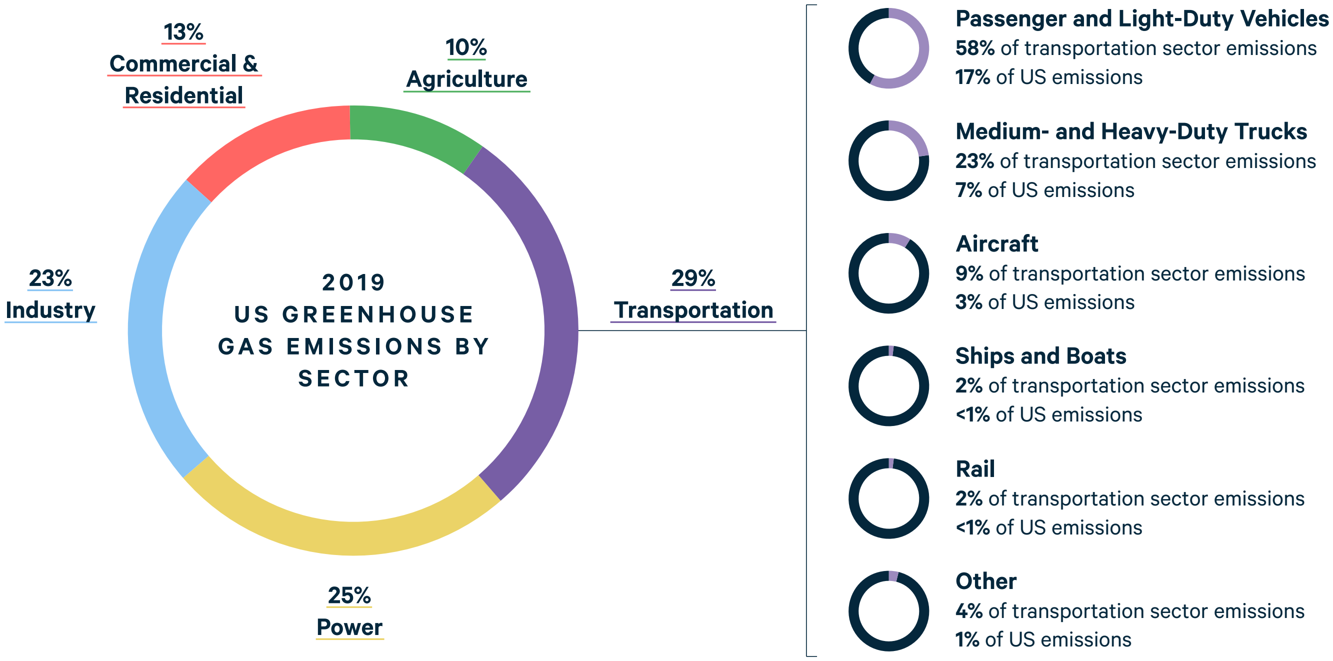
Extended explainer by **Benjamin Leard** — March 2021

1. Introduction

The transportation sector includes economic activity from all forms of travel. People travel daily to and from work or school, visit friends and family, and obtain goods and services. Businesses deliver their goods and services using trucks, ships, trains, and airplanes. To get a good from a production facility to a person's house depends on the transportation sector.

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 greenhouse gas (GHG) emissions. In 2019, transportation was the largest source of GHG emissions in the United States (Figure 1).

Figure 1. Total US Greenhouse Gas Emissions by Economic Sector in 2019



Source: **Inventory of US Greenhouse Gas Emissions and Sinks**

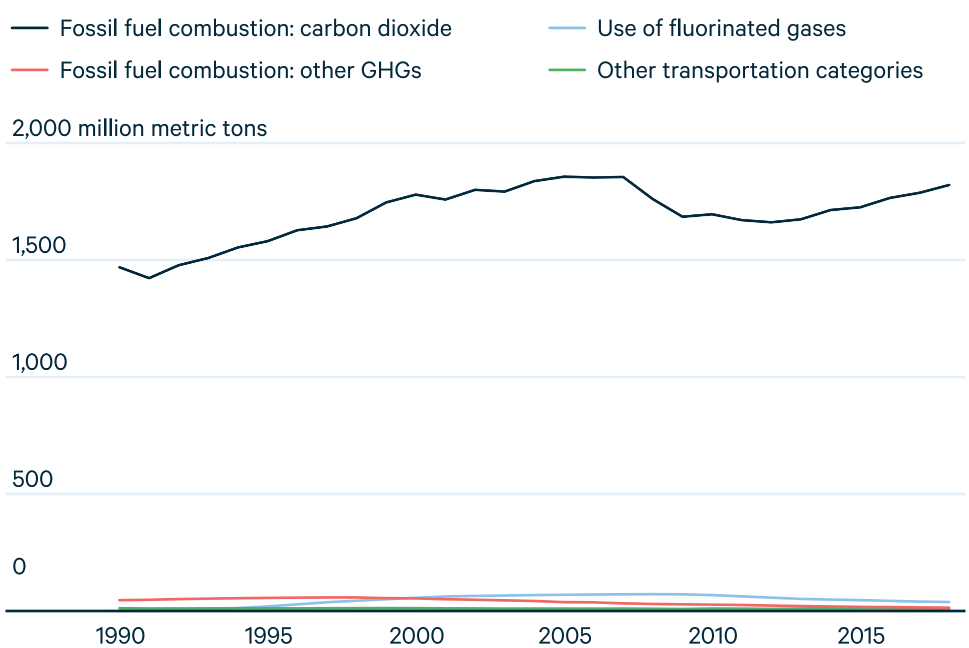
As this sector is a significant source of emissions that contribute to our changing climate, policymakers have developed a series of major federal regulations for reducing transportation emissions. Instead of relying on a single climate policy, such as a **carbon price**, the United States has a patchwork of emissions regulations in the transportation sector. These regulations have taken the form of tradable performance standards and subsidies, including GHG standards for light-, medium-, and heavy-duty vehicles; tax credits for alternative-fuel vehicles; and GHG standards for airplanes. This explainer reviews the other primary 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.

2. Sector Overview

The transportation sector accounted for 29 percent of total GHG emissions in the United States in 2019 (Figure 1). Within this sector, about 59 percent comes from passenger vehicles; 23 percent comes from heavy-duty vehicles; 9 percent comes from aircraft; and the remaining 9 percent is from rail, ships and boats, and other sources.

Over the past 30 years, emissions from the transportation sector **have grown by about 24 percent**.Transportation emissions grew rapidly between 1990–2007, then fell due to slowed economic activity caused by the Great Recession. Since 2012, transportation sector emissions have grown every year, due in part to the steady economic growth during this period.

Figure 2. US Transportation Sector Carbon Dioxide Emissions, 1990–2019

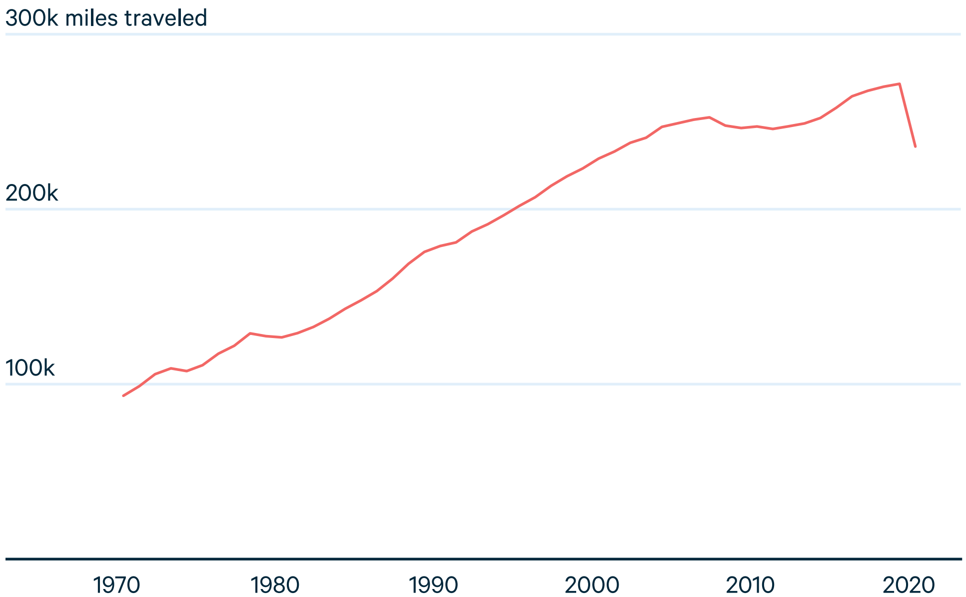


Source: **2019 Environmental Protection Agency Greenhouse Gas Inventory**

The future trajectory of transportation emissions is uncertain. Prior to the COVID-19 pandemic, transportation sector emissions (Figure 2) 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.

Sources of GHG emissions in the transportation sector are generally considered difficult to decarbonize. Decarbonization 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 (Figure 3). 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.

Figure 3. Vehicle Miles Traveled in the United States, 1970–2020



Source: **Federal Reserve Bank of St. Louis**

Because reducing VMT through policy is difficult, transportation sector decarbonization efforts have 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. To read more about pricing carbon in the transportation sector, read "Carbon Pricing 202."

3. 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. For a given amount of lifetime miles traveled, lifetime emissions are inversely proportional to miles per gallon. Hence, 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. This reduces each new vehicle's lifetime emissions in proportion to the stringency of the standards. That is, a doubling of the standards (e.g., from 27 to 54 miles per gallon), is expected to reduce lifetime emissions of new vehicles by 50 percent, assuming that all other characteristics of the vehicles and travel behavior stay the same. A noteworthy feature of the standards is that they only apply to new vehicles.

Benefits and Challenges

As described above, 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, and they save consumers money by ensuring that drivers spend less money on gas for each mile traveled. Historically, fuel economy standards have garnered support from both consumers and policymakers, granting political viability to this policy option.

One drawback of fuel economy and GHG standards for light-, medium-, and heavy-duty vehicles alike is that they create a rebound effect: some vehicle owners decide to drive their vehicles more as their vehicles get better fuel economy, which **increases emissions**.

Another weakness of the standards is that they delay fleet turnover. The 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.

Overall, the standards are expected to reduce GHG emissions; but because of the rebound effect and delayed fleet turnover, the standards generally are an inefficient way to reduce transportation emissions.

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.

Another consideration is the 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.

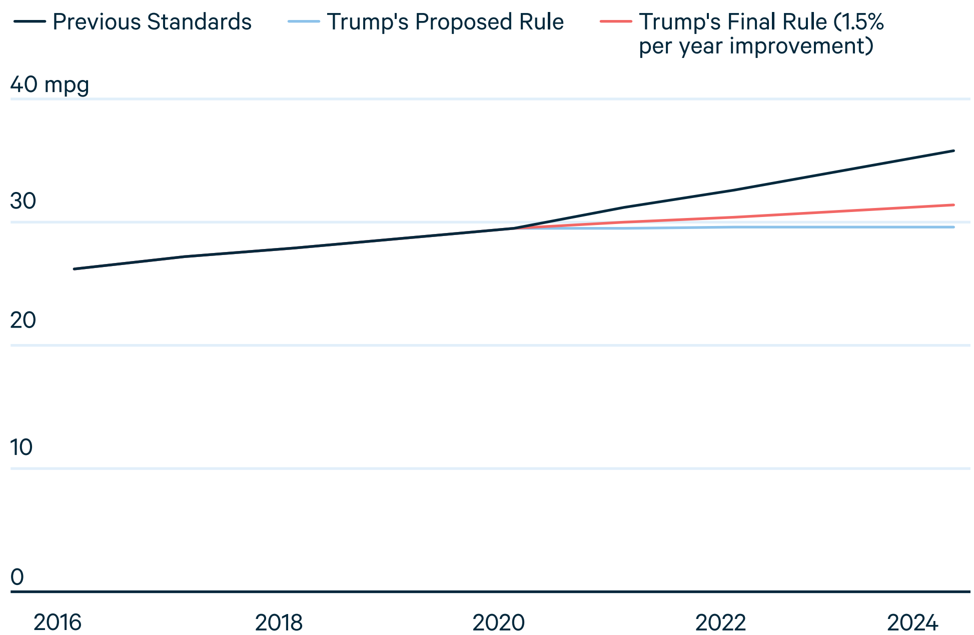
Past, Current, and Proposed Fuel Economy and GHG Standards

Corporate average fuel economy (CAFE) 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. Each regulation requires that the new vehicles sold by manufacturers achieve, on average, set fuel economy and GHG emissions benchmarks. The average requirement for each manufacturer is unique and depends on the composition of vehicles sold. Cars, being lighter weight, traditionally have higher fuel economy standards and lower GHG standards than those that apply to trucks. **Calculations** from the American Council for an Energy-Efficient Economy project predict reductions in fuel consumption for medium- and heavy-duty vehicles, which translate to proportional reductions in GHG emissions of 25 to 50 percent by 2027.

In 2020, the Trump administration replaced the 2021–2025 Obama standards with the Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule, which requires 1.5 percent year-over-year reductions in GHG emissions beginning with the 2021 model year. Figure 4 compares the required fuel economy of the SAFE Vehicles rule to that of the Obama standards.

The US Environmental Protection Agency (EPA) and the National Highway Traffic Safety Administration (NHTSA) jointly regulate the GHG emissions rates and fuel economy of medium- and heavy-duty vehicles. These standards, which are separate from passenger vehicle CAFE and GHG standards, are currently in Phase 2, which cover the years 2018–2027 and aim to reduce tractor trailer emissions by 24 percent relative to 2014–2018 Phase 1 standards.

Figure 4. SAFE Vehicles Rule Standards versus Obama Standards



Source: **National Resources Defense Council**

4. 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. In areas of the country with a relatively clean electricity grid, an increase in EV sales reduces GHG emissions.

Tax credits also have some drawbacks. First, tax credits subsidize vehicle ownership, which can lead to more vehicles being manufactured and driven. An increase in the number of EVs could increase emissions through the production of electricity, even as vehicle emissions fall. Therefore, using renewable energy sources for electricity production will be a vital part of reducing emissions. Another criticism of tax credits is that they are regressive—the federal tax credit currently applies only to the purchase of new EVs, which tend to be bought by relatively wealthy households. Finally, 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.

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. 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 electric vehicle prices.

However, these programs have some drawbacks as well. First, they impose costs on manufacturers, as programs require the introduction and sale of new ZEV models. These manufacturing costs make new vehicles more expensive on average, and households are likely to respond by holding on to their used vehicles for longer, which delays the impact of ZEV programs on reducing gasoline use and GHG emissions. Additionally, ZEV programs have no impact on used vehicles. Because the used vehicle fleet takes decades to turn over, it takes many years for new ZEVs entering the market to have an impact on fleet-wide vehicle emissions. Finally, by imposing new costs on manufacturers, ZEV programs make new vehicles more expensive on average. As a result, households are likely to respond by holding their used vehicles longer, which further delays the impact of ZEV programs on reducing gasoline use and GHG 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 Program** (CVRP), which offers a direct rebate instead of a tax credit and limits eligibility based on household income: single filers with an income above $150,000 or joint filers with income above $300,000 are not eligible for the CVRP.

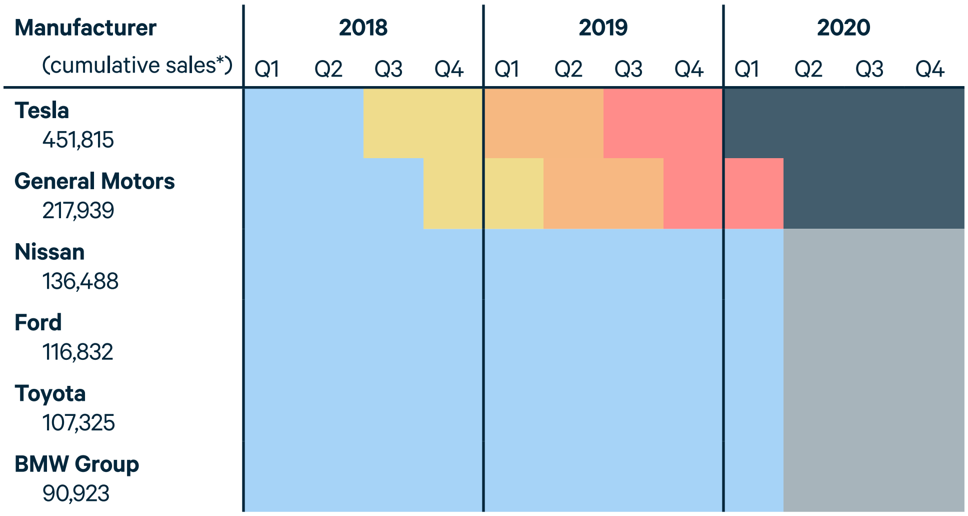
Redesigning the federal EV tax credit to follow the design of the CVRP would make the credit more equitable and would likely make it more cost effective. Since lower-income households are generally more sensitive to vehicle purchase price, redesigning the federal tax credit to attract these households would likely lead 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.

When designing and updating ZEV programs, policymakers can account for several key considerations policymakers can account for: the uncertainty of technological innovation and future costs, the benefit of clear information on credit prices, and the need for flexibility and consistency. If policymakers can factor these into their policy decisions, then programs to expand alternative-fuel vehicles will be more feasible and less costly for automakers. The California ZEV program **illustrates** the importance of these considerations.

Past, Current, and Proposed Alternative-Fuel Vehicle Programs

As described above, federal tax credits are in place to encourage the purchase of EVs. Purchases of new EVs and plug-in hybrid vehicles may entitle car buyers to a credit of up to $7,500 (though this amount varies based on the capacity of the battery used to power the vehicle). The credit makes new EVs more affordable and has led to higher sales of EVs. These tax credits are designed to be phased out after a manufacturer sells at least 200,000 EVs; after a manufacturer meets this threshold, 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. Table 1 shows the historical phaseout of the tax credit.

Table 1. Phaseout Schedule of US Federal Electric Vehicle Tax Credit



Available amount of federal tax credit:

Full amount is available until hitting 200,000 plug-in car sales limit	$7,500
The last two quarters with 100% of the amount	$7,500
Two quarters with 50% of the amount	$3,750
Two quarters with 25% of the amount	$1,875
No credit	
N/A	No data

*Cumulative sales by the end of July 2019, some data estimated

Source: EVadoption.com

The tax 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 5).

Increasingly, state policymakers are adopting ZEV programs as a path toward decarbonizing transportation. Eleven states have ZEV programs: California, Colorado, Connecticut, Maine, Maryland, Massachusetts, New York, New Jersey, Oregon, Rhode Island, and Vermont. 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. California, which is the largest new vehicle market among ZEV states, has EV sales requirements that increase significantly over time, with requirements for about 12–15 percent of sales by the 2025 model year. Figure 6 shows the requirements for model years 2018–2025.

Figure 5. Electric Vehicle Sales by Manufacturers, Relative to Federal Tax Credit Cap (June 2020)

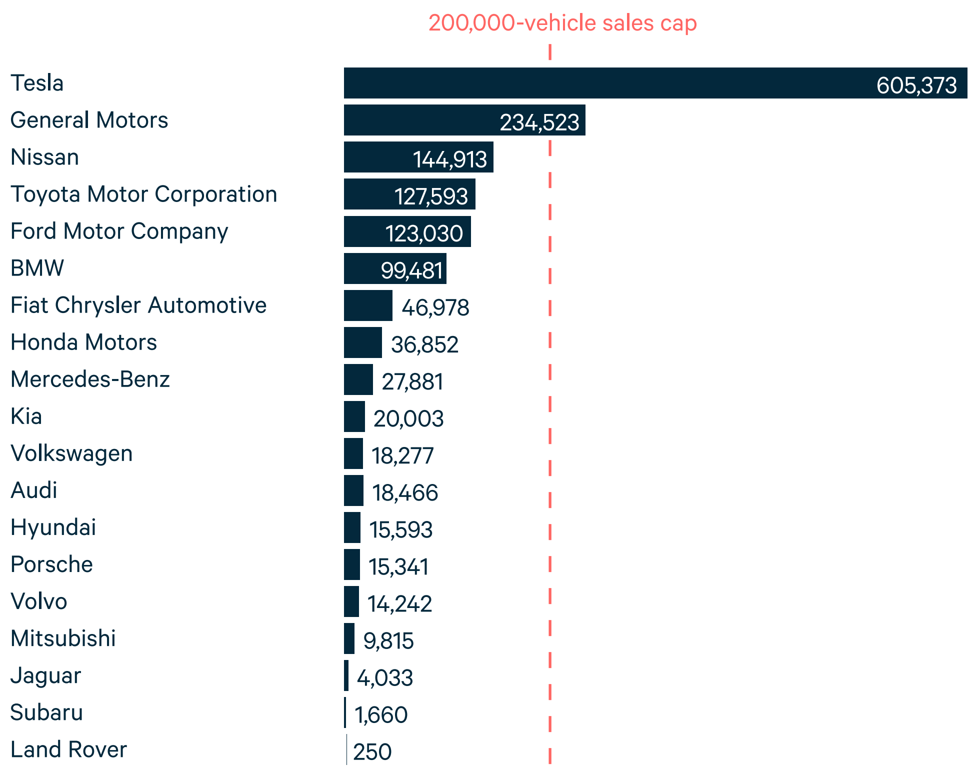
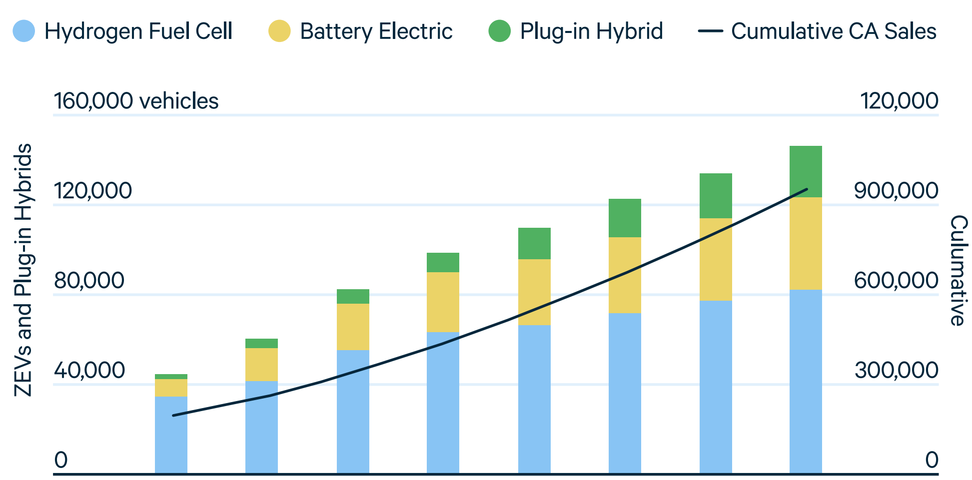


Figure 6. Minimum Expected ZEVs and Plug-In Hybrids in California



Source: **California Air Resources Board**

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** that would ban US sales of new internal combustion engine vehicles by 2035 and require that by 2025, 50 percent of new sales be zero-emission vehicles.

5. 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.

Some of the challenges of reducing aircraft emissions are similar to those of policies listed above. GHG standards for aircraft could encourage innovation in a difficult-to-decarbonize part of the transportation sector. However, this policy has similar drawbacks to fuel economy standards for passenger vehicles—namely, the rebound effect and delayed fleet turnover make this option an inefficient method of reducing emissions.

Key Considerations

The primary considerations for policy design are how high to set the standard and how to measure compliance. Additionally, 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.

Below are descriptions of the current GHG standard designs for aircraft, including relevant notes about how they have been designed.

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.

EPA stated in its benefit-cost analysis that the rule is unlikely to lead to additional benefits. The final rule matches the international standards already in place, which manufacturers are motivated to follow to remain competitive in global markets. Multiple groups have criticized the rule for lack of ambition, and **several states have sued EPA**, asserting that the rule does not go far enough to meet EPA's requirements under the Clean Air Act.

EPA uses fuel efficiency as a metric to assess airplane GHG emissions, because emissions scale with fuel consumption. By focusing on fuel efficiency, the rule accommodates a wide variety of efficiency-boosting measures, including improvements for aerodynamics and engine performance.

The standards are based on a maximum "fuel efficiency metric"—identical to ICAO's emissions metric. Fuel efficiency metric calculations are based on fuselage size and fuel economy.

6. Renewable Fuel Standards and Low-Carbon Fuel Standards

The Basics

Renewable Fuel Standards (RFSs) and **Low-Carbon Fuel Standards** (LCFSs) 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

A benefit of performance standards is that they tend to be more **popular** among consumers than other emissions reduction policies because their costs are less obvious than more direct policies (e.g., a carbon tax). While tax policies have an obvious associated cost of raising fuel and energy prices, the effects of performance standards

are not as evident to the public. The relationship between the RFS and effects on consumers is further complicated by the fact that the RFS likely **affects** multiple interacting markets, namely land and fuel markets—for instance, research suggests that the RFS increases corn prices, but the size of that increase is **challenging to pin down**.

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). But because they target only a subset of actions that can reduce GHG emissions, they are generally less cost-effective than a carbon tax.

A related drawback is that 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. Research has been inconclusive about whether the RFS increases GHG emissions but **has found** that the LCFS likely reduces GHG emissions and that the subsidy effect is moderate.

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. Corn is the main feedstock for fuel ethanol in the United States, and the production of ethanol comes primarily from land conversions to corn crops. These conversions can have unintended impacts on GHG emissions if the original land use had low or negative GHG emissions; for instance, converting forested land to corn crops would increase emissions. However, tracking exactly where the additional feedstock is coming from to produce the renewable fuel can be difficult, so assessing the climate impacts of renewable fuel standards often poses methodological challenges.

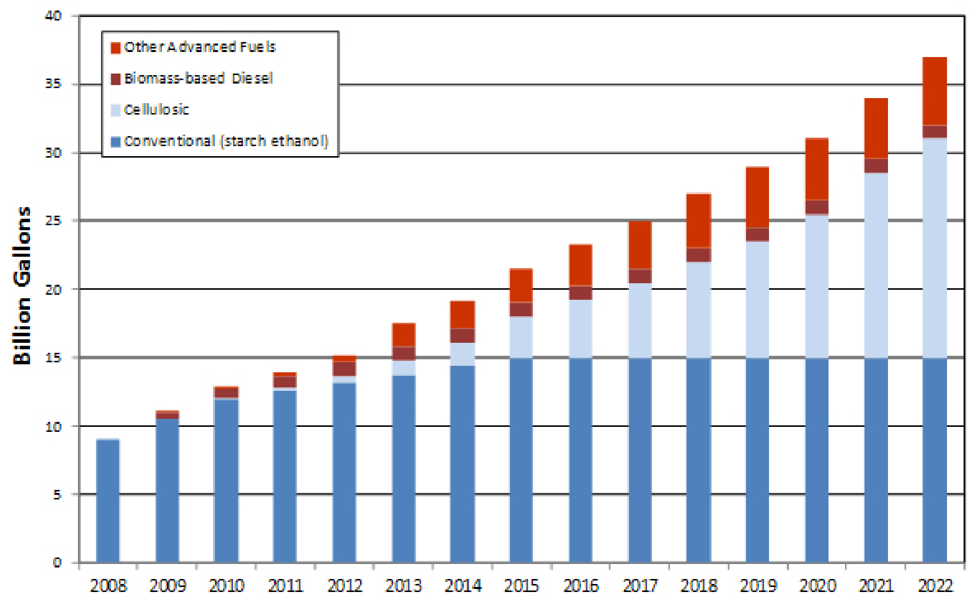
An important consideration for LCFSs is whether to allow regulated entities to earn, buy, and sell regulatory credits. If an LCFS allows for these trades, policymakers should consider areas of potential overlap with other regulations that allow trading. For instance, California allows trades under both its LCFS and its cap-and-trade program.

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. That act defines renewable fuels as those created from biomass, such as ethanol from corn production. The amount of renewable fuel required to be included

in transportation fuel increases each year, and it is scheduled to be 36 billion gallons in 2022. Figure 7 shows the requirements between 2008–2022. The RFS regulates refiners and refined-petroleum product importers. It also includes a tradable permit system.

Figure 7. Renewable Fuel Standard Volumes by Year



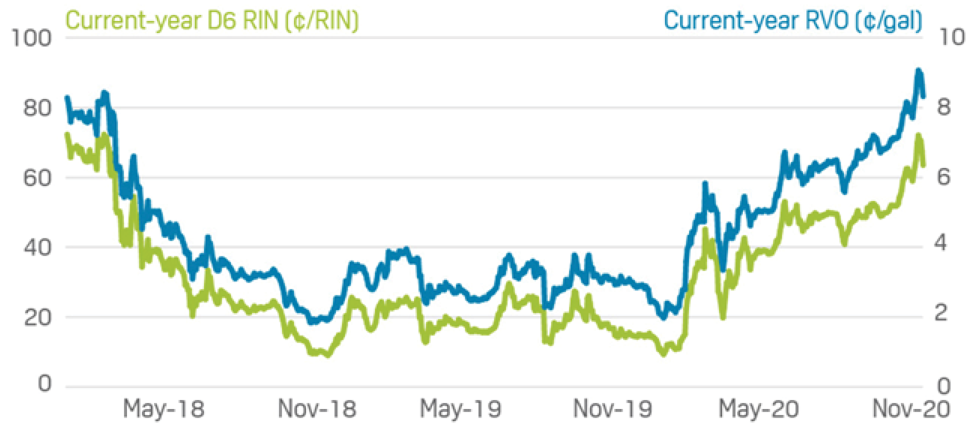
Source: **US Department of Energy**

The RFS includes a tradable permit system where Renewable Identification Numbers (RINs) for fuels are earned, bought, and sold for compliance purposes. Regulated entities—refiners and refined-petroleum product importers—must provide RINs each year to EPA in proportion to the number of gallons of renewable fuels they sell to the fuel market. Regulated entities generate RINs when a renewable fuel is produced or imported.

RIN prices have historically **been volatile**. Figure 8 shows RIN prices from 2018 to the end of 2020. Prices were about 70 cents per RIN at the beginning of 2018, fell to around 20 cents per RIN in 2019, and rose back up to 60 cents by the end of 2020. Much of this volatility has been attributed to changes to the policy in the form of exemptions as well as expected future changes under the Biden administration. During periods when more exemptions were being made under the Trump administration, the demand for RINs fell, which reduced prices. But regulated entities expect fewer exemptions and potentially more stringent requirements after 2022 given the Biden administration's climate commitments, which has increased the demand for and price of RINs.

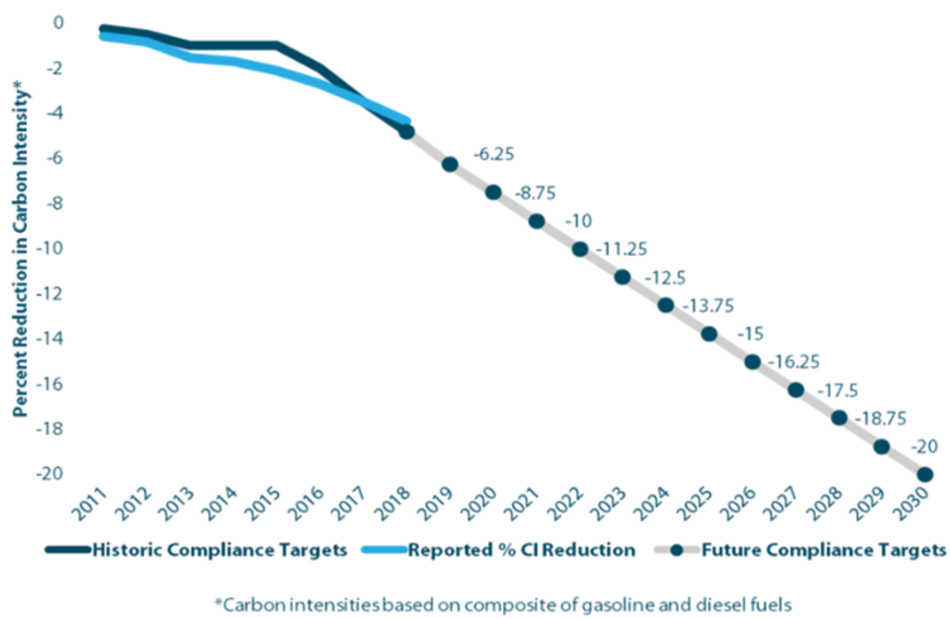
Figure 9 looks closely at California's LCFS and shows the performance and compliance targets between 2011 and 2030.

Figure 8. Renewable Identification Number Prices, 2018-2020



Source: **S&P Global Platts**

Figure 9. California's Low-Carbon Fuel Standard Performance and Compliance Targets



Source: **Breakthrough**

California's LCFS was implemented in 2011. It currently allows regulated entities—petroleum importers, refiners, and wholesalers—to earn, buy, and sell regulatory credits for compliance purposes. The value of credit transactions exceeded $2 billion in 2018. Current credit prices are around $200 per ton of carbon, which exceed most estimates of the social cost of carbon. However, the LCFS overlaps with another relevant

regulation in California, namely the cap-and-trade program for carbon emissions. Comparing credit prices to the social cost of carbon becomes more complex when regulations overlap, as they do here.

The possibility of a federal LFCS has garnered new interest, given that the Biden administration is more receptive to GHG reduction policies than the previous administration. 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.

Benjamin Leard is a university fellow at RFF as well as an assistant professor and faculty fellow at University of Tennessee. He is an environmental economist who focuses his work on transportation policy, climate change, and discrete choice modeling. His recent work involves estimating household preferences for vehicle attributes and evaluating the costs and benefits of fuel economy and greenhouse gas standards for light duty vehicles.