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FOR THE FUTURE

# POLICY BRIEF

APR. 2016 | NO. 16-03

## **Comparing US and EU Approaches to Regulating Automotive Emissions and Fuel Economy**

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### **Key Points**

- Historically, the United States and European Union have taken different approaches to regulating passenger vehicle fuel economy and emissions of greenhouse gases and other pollutants, affecting choices of vehicle engines and fuels.
- The Volkswagen emissions testing scandal will likely have broader implications for the regulation of fuel economy, greenhouse gas emissions, and emissions of other pollutants.
- The scandal has led to a tightening of US emissions testing procedures, whereas EU regulators have responded to widespread noncompliance with current emissions standards by providing manufactures more time to adjust to upcoming standards.
- Some have suggested giving more weight to real-world testing—that is, measuring emissions and fuel consumption from vehicles while on the road, possibly over their lifetimes and not just at the time of certification.

### **Introduction**

In September of 2015, Volkswagen admitted to having programmed nearly 11 million vehicles to cheat on tailpipe emissions tests (Ewing 2016; ICCT 2015a). To put VW's emissions rigging into a broader context, we review the different approaches that the United States and European Union have historically taken in regulating automotive emissions and fuel economy. Moreover, we discuss the scandal's implications for regulatory changes in both regions.

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Automobiles provide tremendous benefits to their users, but they also impose environmental costs to society—harming local air quality and contributing to climate change. Because drivers do not incur these costs directly, automobiles are subject to emissions and fuel economy regulations in most of the world. Underlying the VW scandal are trade-offs between controlling a vehicle’s emissions and improving its performance (for example, its acceleration or power). Volkswagen, like most of the EU carmakers, pursues diesel technology—which, compared with gasoline technology, provides greater fuel economy, resulting in lower greenhouse gas emissions, such as carbon dioxide (CO<sub>2</sub>). Yet, relative to gasoline engines, diesel engines tend to emit more nitrogen oxides and particulate matter,<sup>1</sup> which contribute to the formation of smog. Of late, Volkswagen pursued a “clean diesel” strategy rather aggressively, but when some of its diesel engines couldn’t meet the stringent tailpipe emissions rules without sacrificing performance, the company installed a defeat device that allowed Volkswagen’s cars to circumvent lab tests without affecting on-road performance.

In this policy brief we contrast the US and EU approaches to regulating fuel economy, greenhouse gas emissions, and local pollutants, focusing on light-duty vehicles (i.e., cars and light trucks).<sup>2</sup> We point out the importance of effective testing protocols to assure that automakers comply with the regulations, not only for local air pollutants but also for fuel economy and greenhouse gas emissions.

## The History of US Regulations

Vehicles emit pollutants such as nitrogen oxides, carbon monoxide, and particulates as byproducts of fuel combustion. According to the US Environmental Protection Agency (EPA) and Energy Information Administration, in 2011 light-duty vehicles accounted for one-third of carbon monoxide emissions, about 20 percent of nitrogen oxides emissions, and about one-quarter of CO<sub>2</sub> emissions (EPA 2011). These tailpipe emissions are key ingredients in the formation of smog, and as such can be harmful to human health and the environment (smog refers to visible air pollution; it is generated by such emissions in combination with sunlight, heat, and atmospheric conditions [McCarthy 2007, p. 118]).<sup>3</sup>

The rapid motorization in the United States led to smog becoming a major public health issue during the 1950s and 1960s. Due to the unique weather conditions present in the Los Angeles basin, California experienced some of the worst smog in the nation. The subsequent scientific and regulatory discussions were concentrated in that state (McCarthy 2007). California passed the Motor Vehicle Pollution Control Act in 1959, but it was several

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<sup>1</sup> For an explanation of particulate matter, see <https://www3.epa.gov/pm/>.

<sup>2</sup> We exclude from our discussion medium- and heavy-duty trucks, as well as off-road vehicles, because they are subject to different sets of regulations in both regions.

<sup>3</sup> Tailpipe emissions are also strongly influenced by fuel characteristics such as sulfur content. Both gasoline and diesel fuel are subject to regulatory requirements.

years before the issue was taken up at the federal level. In 1965 the US Congress passed the Clean Air Act and adopted California's 1965 emissions standards as the 1968 federal standards. In 1970 the Clean Air Act Amendments were passed, and the EPA was established. In subsequent negotiations, automakers, regulators, and legislators agreed to phase out lead as a gasoline additive. This was a crucial step in making catalytic technology (which converts harmful pollutants in the tailpipe into less hazardous substances) commercially viable. The first catalytic converter, which reduced hydrocarbon and carbon monoxide emissions from vehicles, was introduced in 1975 models. By 1980, automakers developed an even better catalytic converter, which also reduced nitrogen oxides emissions. Tailpipe emissions requirements have evolved much further since the early 1980s. Today the United States contains a rather complex web of federal and state regulations covering air pollutants that contribute to smog and harm human health and the environment.<sup>4</sup>

Vehicle fuel economy became an important subject in the United States during the 1970s, when oil prices spiked multiple times. Legislators enacted national corporate average fuel economy (CAFE) standards in 1975. Manufacturers needed to roughly double fuel economy by 1985, to 27.5 miles per gallon (average mpg) for cars and to 19.5 mpg for light trucks. Fuel economy standards were tightened again in 2007, to 35.5 average mpg for cars and light trucks, to be achieved by 2016.<sup>5</sup> In 2011, a new target of 54.5 mpg was set, to be met by 2025 (see Figure 1).<sup>6</sup>

The rules for implementing fuel economy standards changed during the second CAFE regime that began in 2007. Originally, as established in the first regime, manufacturers needed to show compliance by meeting separate requirements for cars and light trucks. The compliance mechanism has since been refined, and manufacturers now face standards that for both cars and light trucks are defined by the footprint (roughly the rectangle defined by the four wheels) of their vehicles. Consequently, automakers who sell larger vehicles are

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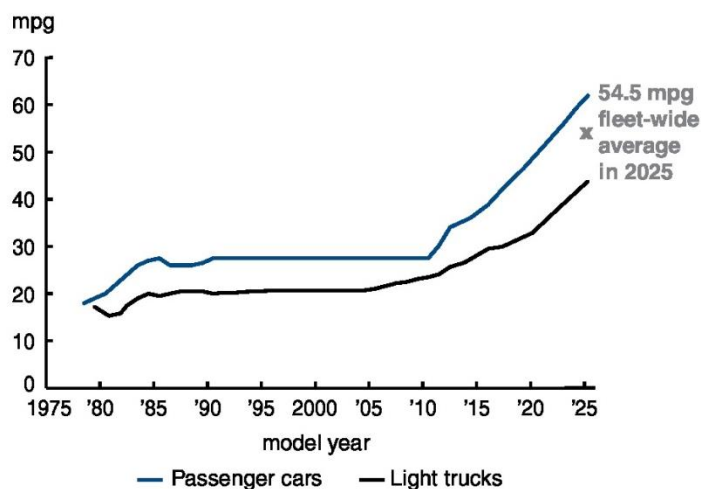
<sup>4</sup> For light-duty vehicles, the tier 3 standards were adopted in 2014 and will phase in from 2017 to 2025. Under tier 2 standards, a manufacturer's fleet average cannot exceed 0.05 grams per mile of nitrogen oxides, which is far below the 0.4 grams per mile standard set in the mid-1970s (EPA 2016a). See EPA (2014) for tier 3 standards.

<sup>5</sup> The 2007 CAFE regulations also introduced controls on vehicle greenhouse gas emissions, and added the EPA as a regulator (the US Department of Transportation alone administered the previous CAFE standards); see Klier and Linn (2011). Initially the regulations required compliance by 2020, but in 2009 the compliance date was moved forward to 2016.

<sup>6</sup> The target of 54.5 mpg for light-duty vehicles is based on the EPA's lab tests. Notably, manufacturers can receive "emissions credits" from the EPA by introducing electric or plug-in hybrid technologies and off-cycle technologies (such as automated engine start-stop systems, which reduce engine idling time). Additional credits can be earned for improving air conditioning efficiency, which reduces greenhouse gas emissions. These credits can be used to offset low-mileage vehicles, thereby keeping an automaker's fleet-wide fuel economy average in compliance with the target. See <https://www3.epa.gov/otaq/climate/documents/420f12051.pdf>.

subject to lower fuel economy requirements. Because of this relationship between a vehicle's footprint and its fuel economy requirement, the recent decline in gasoline prices, which caused sales to shift toward larger vehicles, has reduced the overall level of fuel economy required by the standards, albeit only slightly (Leard et al. 2016).

**FIGURE 1. US FUEL ECONOMY STANDARDS**



*Notes:* The figure displays the evolution of corporate average fuel economy (CAFE) standards—measured in miles per gallon (mpg)—for new passenger cars and light trucks in the United States. See the text for further details.

*Source:* Adapted from <https://www.whitehouse.gov/blog/2012/08/30/what-new-fueleconomy-standards-mean-you>.

## The History of EU Regulations

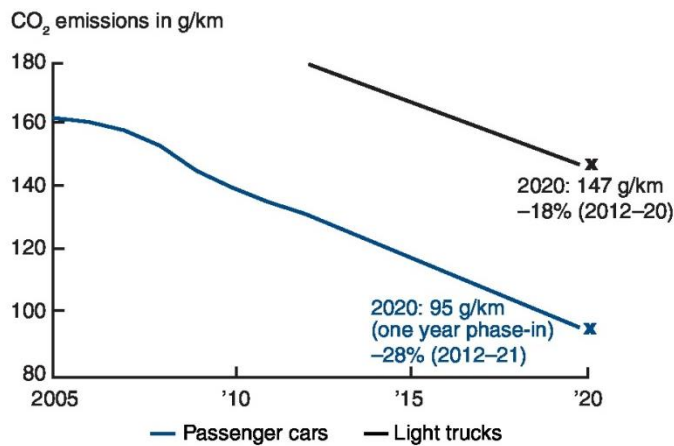
In the European Union, the regulatory goals of emissions and fuel economy were addressed in reverse order: fuel consumption came first. Numerous EU countries responded to the oil shocks of the 1970s by substantially raising fuel taxes to lower fuel consumption.<sup>7</sup> Consequently, EU fuel taxes are much higher than those in the United States. Moreover, many EU countries decided to tax diesel at a lower rate than gasoline (Klier and Linn 2013; Miravete et al. 2015). Partly because of fuel taxes, diesel's share among passenger cars in Western Europe rose from 14 percent in 1990 to 52 percent in 2015 (Ewing 2016).<sup>8</sup>

<sup>7</sup> Miravete et al. (2015) summarize Europe's response to the oil price shock. There is agreement in the economics literature that fuel taxes are more cost effective in reducing fuel consumption than are fuel economy standards.

<sup>8</sup> In the United States, diesel's share among light vehicle sales was zero between 1990 and 2003. In 2015 it stood at just under 3 percent (authors' calculations based on data from Ward's autoinfobank).

In 1998, the European Commission reached an agreement with vehicle manufacturers to reduce the emissions of CO<sub>2</sub> by 25 percent by 2008, to 140 grams of CO<sub>2</sub> per kilometer (g CO<sub>2</sub>/km, or about 40 mpg, which is more stringent than the US CAFE standards at the time).<sup>9</sup> A mandatory requirement, backed by fines for noncompliance, was implemented in 2009; it set a level of 130 g CO<sub>2</sub>/km to be met by 2015. Further tightening of regulations took place in 2012; they also included standards for light commercial vehicles. Passenger cars need to meet a CO<sub>2</sub> emissions target of 95 g/km (equivalent to 57.9 mpg) by 2021, and for light commercial vehicles it is 147 g/km (equivalent to 43.3 mpg) by 2020 (ICCT 2014; see Figure 2). Whereas the US standards depend on a vehicle's footprint, EU standards depend on weight; heavier vehicles are subject to a higher CO<sub>2</sub> emissions requirement (and lower fuel economy).

**FIGURE 2. EUROPEAN FUEL ECONOMY STANDARDS**



*Notes:* The figure displays the evolution of CO<sub>2</sub> emissions standards in grams per kilometer (g/km) for new passenger cars and light trucks in the European Union. The CO<sub>2</sub> emissions rate is a measure of fuel economy. See the text for further details.

*Source:* Adapted from [http://www.theicct.org/sites/default/files/publications/ICCTupdate\\_EU-95gram\\_jan2014.pdf](http://www.theicct.org/sites/default/files/publications/ICCTupdate_EU-95gram_jan2014.pdf).

Compared to the United States, the European Union came late to regulating vehicle emissions of local air pollutants. It started with the so-called “Euro 1” requirements that set nitrogen oxides emissions limits to 0.78 g/km in 1992. Catalytic converters were required in new cars in the European Union at the beginning of the 1990s, and the sale of

<sup>9</sup> A vehicle's CO<sub>2</sub> emissions rate is directly proportional to its fuel consumption rate (measured in gallons per mile) and inversely related to its fuel economy (measured in mpg). The fuel consumption rate is a linear measure, so that reducing from, say, eight to seven gallons per 100 miles saves the same amount of fuel as reducing it from three to two gallons per 100 miles. In contrast, fuel economy (measured in miles per gallon) does not have this property; increasing fuel economy from 20 to 21 miles per gallon saves more fuel than increasing from 30 to 31 miles per gallon.

leaded fuel was largely prohibited across the region by 2000. The United States was ahead of the European Union by a decade on both accounts. In the United States catalytic converters were ubiquitous in new cars by the early 1990s and leaded gasoline was nearly phased out entirely by 1990. Currently the “Euro 6” emissions rules are being implemented. These require nitrogen oxides emissions in 2017 to be 90 percent below 1992 levels. Those emissions standards are less stringent than current US standards.<sup>10</sup>

## The Role of Compliance Tests

The huge numbers of on-road vehicles makes direct measurement of emissions from all vehicles impractical. Instead, vehicle manufacturers play a key role in testing and reporting emissions of their vehicles. Each model year, new vehicles are tested in a laboratory where they are subjected to standardized testing protocols. These tests are required for vehicles to be certified for sale in a market. The outcomes of those tests do not necessarily reflect real-life driving conditions. In response, the EPA adjusts fuel economy ratings of vehicles communicated to US consumers from the laboratory results to better reflect actual driving conditions. Typically, the adjustment reduces the test results by about 20 percent, meaning that the EPA estimates that the testing understates fuel consumption by 20 percent. In addition, the EPA conducts in-use (on-road) testing of vehicles, both at low mileage (at least 10,000 miles) and at high mileage (more than 50,000 miles; Maxwell and He 2012). EU regulators pursue a similar testing approach, but EU tests tend to be less restrictive and do not include in-use testing (Ewing 2016).

In the European Union, there is evidence that the gap between the reported lab tests and real world emissions has been growing. For example, the International Council on Clean Transportation (ICCT) reports a remarkable increase in the divergence between real-world and official CO<sub>2</sub> emissions values in the European Union from about 8 percent in 2001 to 40 percent in 2014, attributing the growing gap to manufacturers’ exploitation of tolerances and flexibilities in the test procedure (ICCT 2015b). Another study, also based on on-road testing, finds the average level of NO<sub>x</sub> emissions from vehicles in the European Union to be seven times the certified Euro 6 emissions limit.

In the United States, in several instances manufacturers have been fined for reporting incorrect data: Hyundai/Kia were fined for overstating the fuel economy on the majority of their 2012 and 2013 model year vehicle models sold in the United States (EPA 2016b), and Ford had to restate the fuel economy of one of its hybrid vehicles in 2013 (EPA 2013).

The Volkswagen scandal dwarfs these previous cases, both in terms of lost sales for the offending company and in potential fines. In the 12 months prior to September 2015,

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<sup>10</sup> One needs to be careful to adjust for differences in the US and EU test cycles when comparing the standards. See for example ICCT (2014), which adjusts the US numbers to the EU test cycles, and Canis and Lattanzio (2014).

diesel vehicles represented just over 13 percent of Volkswagen's US sales. The company has since been prohibited from selling any diesels in the United States.

### **Longer-Term Implications of the Volkswagen Scandal**

In addition to reducing the company's profits in the short term, the Volkswagen scandal will likely have broader implications for the regulation of fuel economy, greenhouse gas emissions, and emissions of other pollutants. Following Volkswagen's admission of circumventing emissions requirements, discussions have taken place on both sides of the Atlantic regarding test improvements to address the gap between lab-based test values and real-world observations. Thus far, the discussions have focused on emissions of local air pollutants, but the divergence between fuel economy testing and real-world performance raises similar concerns. Some have suggested giving more weight to real-world testing—that is, measuring emissions and fuel consumption from vehicles while on the road, possibly over their lifetimes and not just at the time of certification.

Thus far, the US and EU regulators have responded quite differently to the Volkswagen case, partly because of the EU's greater reliance on diesel technology. In the United States, the EPA has changed its emissions certification procedure, adding several tests and additional time to the process (Beene 2016). In contrast, EU officials weakened the testing framework in response to widespread noncompliance with emissions standards in order to provide more time for the auto industry to adjust before the Euro 6 standards are fully applied. Manufacturers will be allowed to exceed the nitrogen oxides emissions standard under real-world driving conditions by 110 percent between September 2017 and the start of 2020, and by 50 percent afterwards (Financial Times 2015).

More broadly, comparing the regulatory approaches and procedures between the United States and the European Union shows that not only can regulatory requirements differ across markets, but they also can influence the choice of vehicle engines and fuels. For example, the diesel engine is a distinctly EU approach to reduce vehicle CO<sub>2</sub> emissions. Similarly, hybrid cars were developed in response to air quality regulations in Japan, and they have subsequently found acceptance in many other markets, including the United States. Diesel fuel remains a key element of the EU's strategy to reduce CO<sub>2</sub> emissions; yet diesel's emissions of nitrogen oxides and small particulates work against improving air quality.

Looking ahead, decisions about how to address environmental challenges will depend on local conditions and public sensitivities. For example, recent occurrences of smog in London and Paris may have shifted the policy discussion in the European Union regarding the future role of diesel (Rosemain 2015). In the United States, prior to the VW scandal, diesel fuel vehicles accounted for a small but growing share of the overall market. Whether more reliable testing or reputational damage affects the prospects of diesel vehicles in the long term, in either region, is an open question. If their share were to fall in either region, the auto industry's reliance on other technologies, such as hybrid and plug-in electric powertrains, would likely rise in order to meet the increasingly stringent emissions and fuel economy standards in the United States and the European Union.

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