Union of Concerned Scientists

FACT SHEET

Review of Light-duty Vehicle Fuel Economy and Emissions Standards

Innovation Wins: Driving Fuel Economy Gains with New Technologies

How gasoline-powered vehicles can exceed 2025 standards

The fossil fuel–powered internal combustion engine is the main energy source for vehicles on the road today, and it will likely remain so at least through 2025. Long a part of our lives, its success is due partly to continued technological advancement. Since the mid-1970s, the average conventional vehicle has gotten about 60 percent more efficient.[1] Moreover, these advances are accelerating, thanks to efforts to meet the nation's fuel-economy and emissions standards (CAR 2014, UCS 2016).

Investments in innovation have led to novel, cost-effective technologies, enabling the automotive industry to achieve the goals set out in the standards, at costs lower than industry anticipated. The technologies are providing automakers with improved flexibility and creating opportunities for even greater emissions and oil savings. Now in the pipeline or on the drawing boards are several technologies not even anticipated by regulators when today's standards went into place.

Gasoline-powered Engines: Getting Even Better

Most of the energy stored in gasoline does not help move your car. For a typical car, 60 percent of the fuel's energy content is lost in the engine as heat during the combustion process (Figure 1). Then roughly one-third of piston-driving energy is lost to friction, pumping losses when taking in air and exhausting gas out of the combustion chamber, and non-propulsion work such as running the oil pump or other accessories.

A number of strategies can reduce energy losses in an engine, and many of which are already being deployed. Even more are beginning to make their way into the nation's fleet.

HIGH-COMPRESSION ENGINES: MORE POWER, LESS VOLUME

Larger engines increase friction losses so optimizing engine design means getting the most power out of the smallest volume. Increasingly, this is achieved by using a turbocharger, which pushes more air into the cylinder, generating more power with each combustion event.

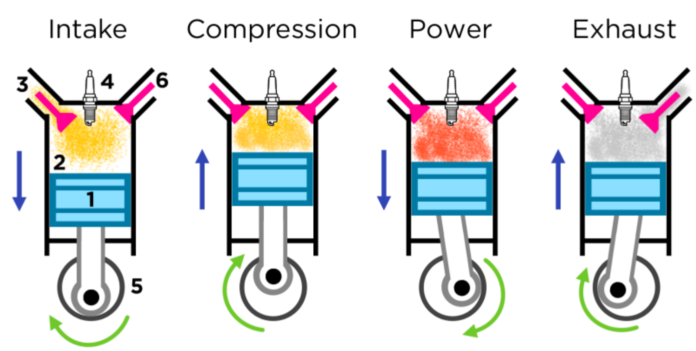
An alternative approach to generating equal power from a smaller engine is to improve the compression ratio. This is the ratio between the largest volume contained by the piston cylinder (during intake) and the smallest volume (during compression). Using this technology, not considered during the regulators' analysis underpinning the rule, an investment of just a few hundred dollars can reduce fuel use by 10 to 15 percent (Duleep 2014, Isenstadt *et al.* 2016). Mazda's SKYACTIV engine is one example of a more effective, high-compression engine.

CYLINDER DEACTIVATION: REAL-TIME DOWNSIZING

Cylinder deactivation is like making your engine smaller on demand. If the vehicle does not need the power, it can "turn off" some cylinders, saving fuel and reducing pumping losses.

This technology, introduced 35 years ago, is available in some large engines today. With advances in cylinder control, this low-cost, right-sizing approach can be applied more seamlessly, making it possible for use with smaller engines. The regulators' pathway to meeting the standards anticipated no adoption of this technology in 2025, yet manufacturers and suppliers now use it to "virtually downsize" smaller engines. The yield: improvements of 10 percent or more (Delphi n.d.).

FIGURE 1. The basics of a gasoline engine



A four-stage cycle underlies a typical gasoline combustion engine. During intake, the piston (1) recedes, pulling air and fuel into the chamber (2). When the intake valve (3) closes, the piston compresses the air-fuel mixture. The sparkplug (4) ignites the mixture, releasing heat, forcing the piston downward, and turning the crankshaft (5). When the exhaust valve (6) is opened, the spent air-fuel is pulled out and the cycle repeats itself. A typical engine has four to eight cylinders, each undergoing this cycle in a precise timing to power the vehicle continuously.

BETTER TRANSMISSIONS: KEEPING THE ENGINE EFFICIENT

An engine operates best within a narrow range of speed and power. Just as on a bicycle, different gears help keep the energy source (a person's legs or a car's engine) at its most efficient operating condition. This is the role of a transmission.

Fifteen years ago, the most common passenger vehicles had four forward gears. Today, eight- and nine-speed transmissions are hitting the road. Continuously variable transmissions (CVTs) act as an infinite set of gears—no matter what the vehicle's speed, a CVT can find the optimal "gear" for engine operation.

The regulators anticipated transmission improvements but not CVTs or transmissions with more than eight gears. Already, these are being widely deployed, for example in the 2017 Ford F-150, 2016 Honda Accord, and across all Subaru models.

Smarter Vehicle Design: Less Work

It is critical to make engines use less fuel to do the same amount of work. Reducing the amount of work necessary to move a vehicle can reduce fuel use as well.

LIGHTER VEHICLES: LESS ENERGY TO MOVE

The less a car weighs, the less energy it takes to move it. Lighter cars need less fuel and can operate with smaller engines. For decades, manufacturers have added weight to cars, whether for safety, comfort, or just more power. Advancements in materials science, computer modeling, and vehicle design can make this possible without decreasing efficiency. A car built with today's higher-strength steels and new aluminum alloys can provide the same level of safety with less material and less weight. More advanced materials like carbon fiber can reduce the weight further.

The federal agencies overseeing standards significantly underestimated the potential impact of lightweight materials on fuel use. In fact, many of today's vehicles have reduced weight beyond expectations. For example, the latest Chevy Malibu sheds nearly 10 percent of its curb weight through the use of both aluminum and high-strength steel.

48 VOLT STOP-START: ELIMINATING IDLE, PROVIDING BOOST

Park a typical vehicle at a stoplight, and the engine keeps running, wasting fuel. Hybrids turn the idling engine off to save fuel; new "stop-start" systems now mimic this in non-hybrids.

An improved system, just coming on the market, can make this approach even more attractive. The average car has a 12 volt battery, which limits the size of the electric motor used to restart the combustion engine as well as the types of electrical devices that can be run off that battery. The higher voltage on new 48V electric systems generate more power—so they can work with a bigger, more responsive electric motor. Also, electric turbochargers can run off a 48V system, again helping reduce the size of the engine needed.

When the rules were written, the regulators did not foresee 48V stop-start systems that could get most of the benefits of a hybrid at a lower cost. Yet today's suppliers are readying them for deployment (Carney 2016).

Exceeding Expectations Today: What About 2025?

These diverse technologies represent a handful of the many ways in which conventional, gasoline-powered vehicles are improving beyond what federal agencies foresaw when conceiving the rules, and nearly a decade remains for continued innovation by the 2025 target date.

The effort to meet strong standards has paid off, and investments in research by automakers and suppliers yield dividends today. Automakers are well ahead of the standards, and many technologies have surpassed the agencies' initial projections for 2025.

The question is not whether or not manufacturers can meet the standards in 2025. Clearly, they can not only meet them but exceed them. The really exciting question is, what novel technologies will surprise us next?

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ENDNOTES

1 When normalized to size and power, modern conventional vehicles use 60 percent less fuel per mile. See UCS 2016.

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