Pickup Trucks, New Technologies, and Savings at the Pump

Pickup truck fuel economy is on the rise. EPA's latest Fuel Economy Trends report shows that average fuel economy for new pickups increased from 16.9 mpg in 2010 to 19.0 mpg in 2016.[1] That will save the average driver about $200 in fuel expenditures per year, even at current low gasoline prices. How are manufacturers accomplishing these gains—and doing it without sacrificing power? Through steady, incremental advances in vehicle technology.

MANUFACTURERS ADDING TECHNOLOGY

Pickup truck production in the United States is dominated by the Detroit Three: Ford, General Motors, and Chrysler (as part of Fiat-Chrysler). All three manufacturers are putting new technologies in their pickup trucks. Ford has outfitted the best-selling F series pickups with its proprietary EcoBoost system, which combines a turbocharged, downsized engine with gasoline direct injection to improve fuel economy, peak power, and torque. Today, Ford pickups sold with EcoBoost are also equipped with auto start-stop systems. In addition, all Ford trucks have shed approximately 700 lbs., or 12-14% of their weight, since 2014, allowing them to go further on a gallon of fuel.

GM and Chrysler have also added engineering sophistication to their pickup truck lineups. Chevy, GMC, and Ram trucks offer cylinder deactivation and 8-speed transmissions with high-efficiency gearboxes on most models.

These ongoing miles-per-gallon gains draw largely from evolutionary technology improvements that are appearing in the market at a fast clip, thanks in large part to rising federal fuel economy (CAFE) standards. Manufacturers are finding ways to add technologies that pay for themselves in fuel savings over time and often improve other features, such as handling, as well.

TOP TECHNOLOGIES

Pickup trucks on the market today use a variety of technologies to boost fuel economy.

Cylinder deactivation – Cylinder deactivation selectively turns off intake and exhaust valves and prevents fuel injection into some cylinders in the engine during light-load operation. In large-displacement engines, the vehicle's throttle valve is only partially open during light-load driving, which leads to pumping losses. Deactivating cylinders allows this throttle valve to open more fully, allowing air to flow more freely, which reduces drag on the pistons and pumping losses.

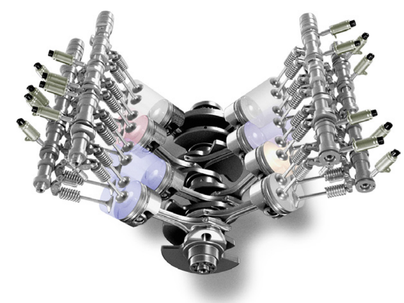

Figure 1: Cylinder deactivation. Source: Audi

8-speed transmission and high-efficiency gearbox – Automatic transmissions with more gears can improve fuel economy by enabling the engine to operate at high efficiency over a broader range of vehicle operating conditions. A high-efficiency gearbox reduces frictional and other parasitic losses in the system.

Gasoline direct injection – Direct injection improves fuel economy by precisely injecting highly pressurized gasoline fuel directly into the combustion chamber of each cylinder, thus reducing piston pumping losses and improving thermodynamic efficiency. It has been used for years in diesel engines and is one of the primary reasons why diesel engines have higher fuel economy than their gasoline counterparts. Today, direct injection is increasingly being incorporated into gasoline-fueled engines.

Turbocharging – Turbocharging increases the power output of an engine by forcing exhaust gas into the combustion chamber, allowing a reduced engine size without sacrificing power. It enables the use of smaller engines (downsizing). Turbocharging and downsizing are typically combined with gasoline direct-injection technology.

Cooled Exhaust Gas Recirculation (EGR) – EGR systems improve fuel efficiency by recirculating some of the vehicle's exhaust gas back to the engine cylinder to mix it into the fresh intake. Mixing exhaust with the intake air lowers combustion temperatures and rates, which enables a higher compression ratio without engine knocking, thus improving fuel economy.

Lightweighting – Reducing a vehicle's weight through the use of advanced materials such as high-strength steel, aluminum, and carbon fiber, along with secondary reductions through re-optimization of vehicle systems, improves fuel economy by reducing the amount of energy needed to accelerate and move the vehicle.

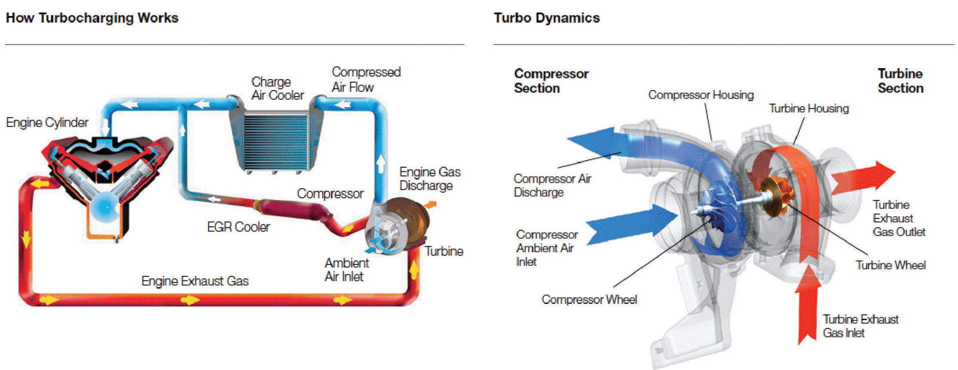

Figure 2: Turbocharging system. Source: Honeywell

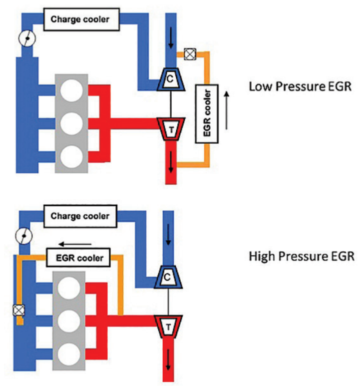

Figure 3: Cooled EGR system. Source: SAE International

Auto start-stop – Auto start-stop or idle-stop technology turns a vehicle's engine off automatically at stops, which saves fuel. The engine restarts when the brake is released. This system can be run off the existing battery and is often called a 12-volt micro hybrid.

FUEL EFFICIENCY GAINS AND PAYBACK TO CONSUMER

Manufacturers' implementations of these technologies differ greatly. Cost and effectiveness of the specific implementations are hard to come by, because they are proprietary information. However, federal agencies estimated effectiveness and cost for these technologies as part of a midterm evaluation process for the fuel economy and greenhouse gas emissions standards.[3] These estimates are shown in Table 1.

Table 1. Fuel efficiency increase, cost, and payback period for effiency technologies

Technology	Fuel efficiency increase (%)	Cost to consumer (2017)	Payback period (years)
Cylinder deactivation	4.6	$230	2.7
8-speed transmission with high efficiency gearbox	5.5	$230	2.3
Advanced 8-speed transmission with high efficiency gearbox	9.4	$516	3.1
Gasoline direct injection (V6 engine)	1.5	$454	16.2
Turbocharging	9.8	$805	4.7
Cooled EGR	3.6	$332	5.0
Lightweighting	7.7	$663	4.8
Auto start-stop	3.7	$469	6.8

Sources: Fuel efficiency and cost from EPA and NHTSA Draft Technical Assessment Report (2016); simple payback calculated by ACEEE.

Table 1 also shows estimated costs to the consumer. These include the cost of technology R&D, the cost of manufacture, and retail markup. The table also shows the simple payback for each technology, which is the approximate number of years it will take to pay off these incremental costs with the gasoline savings resulting from that technology. We assume that the average vehicle travels 15,000 miles annually and use a baseline fuel economy for pickup trucks of 19 mpg[4] and a per-gallon cost of gasoline of $2.42.[5]

Most of the technologies shown in table 1 pay back within 5 years. Cylinder deactivation and transmission improvements have the shortest payback. Two technologies highlighted do not pay back in 5 years, but are making inroads in today's vehicles nonetheless. For instance, manufacturers include gasoline direct injection to reduce engine knocking and also to enable other advanced technologies including turbocharging and Atkinson cycle and Miller cycle engines. Auto start-stop also has a higher payback period at present, but its penetration in the market is still low. The cost of auto start-stop is projected to fall by more than $100 by 2025. Other technologies' costs will also fall as they are deployed in more and more vehicles.

FUEL ECONOMY STANDARDS AND MARKET TRENDS

The influx of efficiency technologies will continue as the global vehicle market moves steadily toward highly efficient, low-emitting vehicles. Fuel economy standards help ensure that auto manufacturers steadily incorporate new technologies into their best-selling pickups despite fluctuations in fuel prices. Fuel prices are likely to rise again. But even at today's relatively low fuel prices, lifetime net savings for pickup owners from these new technologies would be substantial.

NOTES

1. EPA Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2016, available at https://www.epa.gov/fuel-economy/trends-report

2. https://turbo.honeywell.com/turbo-basics/turbo-fundamentals/

3. EPA and NHTSA (2016), Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025 Draft Technical Assessment Report, July 2016. Available at https://nepis.epa.gov/Exe/ZyPDF.cgi/P100OXEO.PDF?Dockey=P100OXEO.PDF

4. http://cta.ornl.gov/data/spreadsheets.shtml

5. Regular gasoline price on 4/10/2017, https://www.eia.gov/petroleum/gasdiesel/, Accessed on 4/13/2017