Climate Change and the Environment

We have comprehensive strategies and goals for minimizing our environmental impacts, including reducing our contribution to climate change.

Read more about OUR APPROACH TO CLIMATE CHANGE AND THE ENVIRONMENT

CLIMATE CHANGE STRATEGY

Ford has a science-based strategy to reduce greenhouse gas (GHG) emissions from our products and operations that focuses on doing our share to stabilize carbon dioxide (CO_2) concentrations in the atmosphere.

Read more about OUR STRATEGY, COMMITMENT AND PROGRESS

OUR GOALS AND PERFORMANCE PROGRESS

Goal: For each of our new or significantly refreshed vehicles, continue to offer a powertrain with leading fuel economy.

We reduced the average CO_2 emissions of our European car fleet by 18% between 2007 and

2013. In the U.S. in 2013, we improved the average fuel economy of our car fleet by 2% and of our truck fleet by 3% compared with 2012.[1]

Goal: Reduce CO_2 emissions from our facilities by 30% per vehicle produced from 2010 to 2025.

In 2013, we reduced facilities CO_2 emissions per vehicle produced by 9% and average energy consumed per vehicle produced by 4% compared with 2012.

Goal: Reduce waste sent to landfill by 40% on a per-vehicle basis between 2011 and 2016 globally.

We reduced waste to landfill per vehicle produced by 14% in 2013 compared with 2012.

See more at FORD'S GOALS, COMMITMENTS AND STATUS

SUSTAINABLE TECHNOLOGIES AND ALTERNATIVE FUELS PLAN

Our sustainable technologies and alternative fuels plan is our route to improving fuel economy and cutting the CO_2 emissions of our products around the world. We have already implemented all of the near-term and many of the mid-term elements of this plan.

Read more about our SUSTAINABLE TECHNOLOGIES AND ALTERNATIVE FUELS PLAN

Case Study: HELPING FLEET CUSTOMERS MEET ENVIRONMENTAL AND COST GOALS

We have developed a suite of purchasing tools to help fleet customers understand the most cost-effective ways to reduce the carbon emissions of their vehicle fleets, helping them meet environmental and financial goals simultaneously.

Voice: JOHN FLEMING

Executive Vice President, Global Manufacturing and Labor Affairs, Ford Motor Company

"When we consider building a new plant, we look at the same issues no matter where we are thinking of locating the facility – air emissions, water usage, waste water and waste. But of course the emphases may vary depending on the local conditions."

ELECTRIFICATION

We are taking a comprehensive approach to electrified vehicles (EVs). We have introduced six EV products. We are developing a suite of customer support tools such as charging station locaters and fuel-efficiency tracking apps and working with utilities, cities and other partners to develop an electrified vehicle ecosystem that facilitates the adoption and use of EVs.

Read more in ELECTRIFICATION: A CLOSER LOOK

2013 HIGHLIGHTS

114 million +

all-electric miles driven by Ford full battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) customers so far, resulting in an 8 million kg reduction in CO_2 compared to gasoline-powered miles.

100%

of Ford vehicles produced in North America have used soy foam seating since 2011.

1. Our U.S. combined car and truck corporate average fuel economy decreased by 1.7% in 2013 due to increased customer demand for trucks versus cars.

Climate Change and the Environment

- > Overview
- Climate Change
- Greening Our Products
- Greening Our Operations
- Data
- Case Study: Ford Fleet Purchase Planner
- Voice: John Fleming

Overview

At Ford, we have been working for many years to reduce the environmental impacts of our vehicles and operations.

For example, we are doing our part to prevent or reduce the potential for environmental, economic and social harm due to climate change. We have a science-based strategy to reduce greenhouse gas (GHG) emissions from our products and operations that focuses on doing our share to stabilize carbon dioxide (CO_2) concentrations in the atmosphere. We are on track to meet the central elements of our strategy: For each of our new or significantly refreshed vehicles, we will continue to offer a powertrain with leading fuel economy and we are reducing GHG emissions across our global product portfolio. We have also set a goal to reduce our facility CO_2 emissions per vehicle by 30 percent by 2025 compared to a 2010 baseline, building on our reduction of 31 percent from 2000 to 2010.

We are committed to reducing other elements of the environmental footprint of our vehicles and operations as well. For example, we continue to increase the use of sustainable materials in our vehicles. And, we reduced waste to landfill by 14 percent per vehicle produced from 2012 to 2013 and are implementing a plan to reduce waste sent to landfill by 40 percent on a per-vehicle basis between 2011 and 2016 globally. We are also continuing to reduce emissions of volatile organic compounds from our operations through the use of innovative technologies.

In this section we discuss our approach to the issue of climate change and the ways we are working to reduce the environmental footprint of our products and operations.

LIVING THE ELECTRIC LIFESTYLE

To help drivers make the transition to electric vehicles (EVs), and get the most out of their EVs, we are offering more than just the vehicle. We are delivering a total electric vehicle lifestyle.

Case Study: FORD FLEET PURCHASE PLANNER

We have developed a suite of purchasing tools to help fleet customers understand the most cost-effective ways to reduce the carbon emissions of their vehicle fleets, helping them meet environmental and financial goals simultaneously.

Home > Climate Change and the Environment > **Overview**

Climate Change

Ford is committed to doing our share to prevent or reduce the potential for environmental, economic and social harm due to climate change.

We have a comprehensive, science-based global strategy to reduce greenhouse gas (GHG) emissions from our products and processes while working cooperatively with the public and private sectors to advance climate change solutions. We are taking a holistic approach to the issue, recognizing that it affects all parts of our business and is interconnected to other important issues, from water availability and energy security to human rights.

We believe our commitment to addressing the climate change issue in a comprehensive and strategic way is one of the factors that has helped to positively transform our company's current and future products and prospects.

Our Commitment

Our climate change strategy is based on doing our share to stabilize the atmospheric concentration of carbon dioxide (CO_2) at 450 parts per million (ppm), the level that many scientists, businesses and governmental agencies believe may avoid the most serious effects of climate change. This commitment includes the following:

- For each of our new or significantly refreshed vehicles, we will continue to offer a popular version powertrain with leading fuel economy.
- From our global portfolio of products, we will reduce GHG emissions consistent with doing our part for climate stabilization – even taking into account sales growth.
- We will reduce our facility CO_2 emissions by 30 percent from 2010 to 2025 on a per-vehicle basis, and average energy consumed per vehicle by 25 percent from 2011 to 2016 globally.

For an in-depth look at the science behind our commitment, please see Ford's Science-Based CO_2 Targets.

Our technology migration plan for achieving vehicle CO_2 emissions reductions – embodied in our Sustainable Technologies and Alternative Fuels Plan – maps the road we're taking to achieve our product goals.

Our Progress

We are on track to meet our commitments. We are making progress by adding advanced technologies to all our products and offering high-value, attractive models that are more fuel efficient while still meeting customer expectations for utility and performance. We also continue to invest in energy-efficiency improvements at our facilities worldwide and to assess carbon emissions in our supply chain through multi-stakeholder projects.

Among our recent and upcoming actions, we:

- Reduced fleet-average fuel economy from our U.S. car fleet by 2 percent and our U.S. truck fleet by 3 percent in 2012 compared with 2013.[1]
- Reduced fleet-average CO_2 emissions from our European vehicles by 18 percent from the 2007 to 2013 calendar years.
- Reduced CO_2 emissions from our global operations in 2013 by 9 percent per vehicle produced, compared to 2012.
- Implemented our sixth engine model with our patented EcoBoost® fuel-saving technology, a 2.7L engine that will debut in the all-new 2015 Ford F-150. We will also debut a new 2.3L EcoBoost engine in our 2015 Lincoln MKC, and later in the 2015 Mustang.
- Exceeded our goal of producing 1.5 million EcoBoost engines globally by 2013,

Related links

This Report

- Greening Our Products
- Greening Our Operations
- Sustainable Technologies and Alternative Fuels Plan
- Electrification: A Closer Look
- Vehicle Fuel Efficiency and CO_2 Progress and Performance

instead producing more than 2 million.

- Sold nearly 2.5 times as many electrified vehicles in 2013 as in 2012, including our Focus Electric (a battery electric vehicle) and C MAX Energi and Fusion Energi (plug-in hybrid electric vehicles), leading the market in plug-in hybrid sales for the fourth quarter of 2013.
- Saw Ford electric vehicle customers drive over 114 million all-electric miles as of late April 2014, for a net CO_2 reduction of nearly 8 million kgs compared to gasoline-powered driving.
- Continued to offer three hybrid electric vehicle models: the Ford Fusion, Ford C MAX and Lincoln MKZ.
- In Europe, offered 48 models and variants that achieve a CO_2 emissions level of 130 grams per kilometer (g/km), and 13 that achieve less than 100 g/km.

We discuss our progress on vehicle fuel efficiency and CO_2 emissions in more detail in the Greening Our Products section and our progress in reducing facility-related energy use and CO_2 emissions in the Greening Our Operations section.

Supporting Climate Change Policies

Neither Ford nor the auto industry can achieve climate stabilization alone. Reducing emissions by the amount required calls for an integrated approach – a partnership of all stakeholders, including the automotive industry, the fuel industry, government and consumers. It can only be achieved by significantly and continuously reducing GHG emissions over a period of decades in all sectors of the economy. In the transportation sector, this means improving vehicle fuel economy, developing lower-carbon fuels and working with the government on complementary measures to encourage consumers to purchase these more fuel-efficient vehicles and lower-carbon fuels. We are committed to working with all key stakeholders to create policies that further promote the development of lower-carbon fuels and other complementary measures.

If there is a mismatch between available fuels, vehicles and consumers, climate stabilization goals will not be met. Accordingly, we are committed to advocating for effective and appropriate climate change policy. We are promoting comprehensive market-based policy approaches that will provide a coherent framework for GHG emission reductions, so that companies like ours can move forward in transforming their businesses with a clear understanding of their obligations. For more information on climate change policies globally please see Climate Change Policy and Partnerships.

In This Section

In this section we first provide an overview of the climate change issue and of Ford's greenhouse gas emissions. We also discuss the risks and opportunities that climate change poses for Ford and our overall climate change strategy. Finally we discuss climate change public policy issues and Ford's climate change partnerships.

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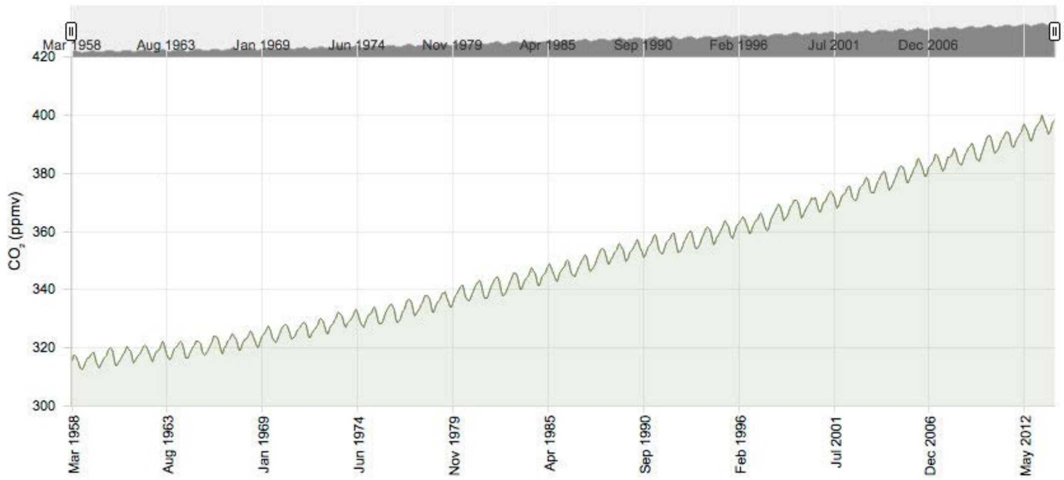
1. However, our combined U.S. corporate average fuel economy declined by 1.7 percent in 2013 due to increased customer demand for trucks over cars.

The Issue

Climate change is the result of an increase in heat-trapping (greenhouse) gases in the atmosphere. Carbon dioxide (CO_2) is the major long-lived greenhouse gas (GHG). The burning of fossil fuels (to provide electricity, heat and transportation, and to support industry and agriculture), as well as deforestation, leads to net emissions of CO_2 and increased levels of atmospheric CO_2. The atmospheric concentration of CO_2 has increased from a preindustrial level of 270 to 280 parts per million (ppm) to a level of approximately 394 ppm at the beginning of 2013 (see Figure 1).

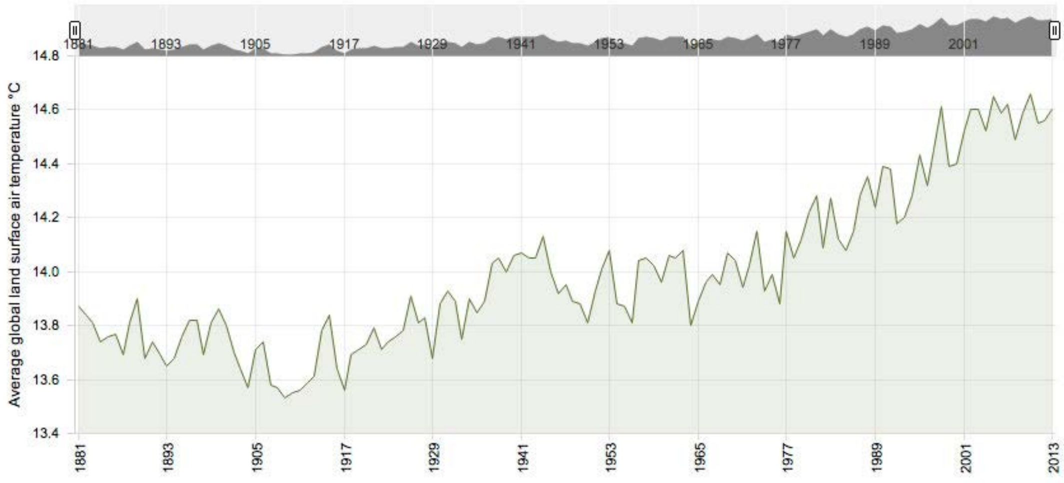
Global temperature records have been reported independently by scientists at the National Aeronautics and Space Administration (NASA) in the U.S., the National Oceanic and Atmospheric Administration (NOAA) in the U.S., the Climate Research Unit at the University of East Anglia in the U.K., and the Japanese Meteorological Agency. The records from these four independent groups are in good agreement and show a distinct warming trend over the past century. The past decade was the warmest decade in the instrumental temperature record. As shown in Figure 2, 2013 was among the warmest years on record. Independent measurements of rising sea levels, increasing acidification of the oceans, loss of Arctic sea ice and the retreat of glaciers around the world are consistent with the impact of rising GHG concentrations and global temperature.

Figure 1: CO_2 concentration measured at the observatory in Mauna Loa, Hawaii



Data source: NOAA (2014)

Figure 2: Global temperature



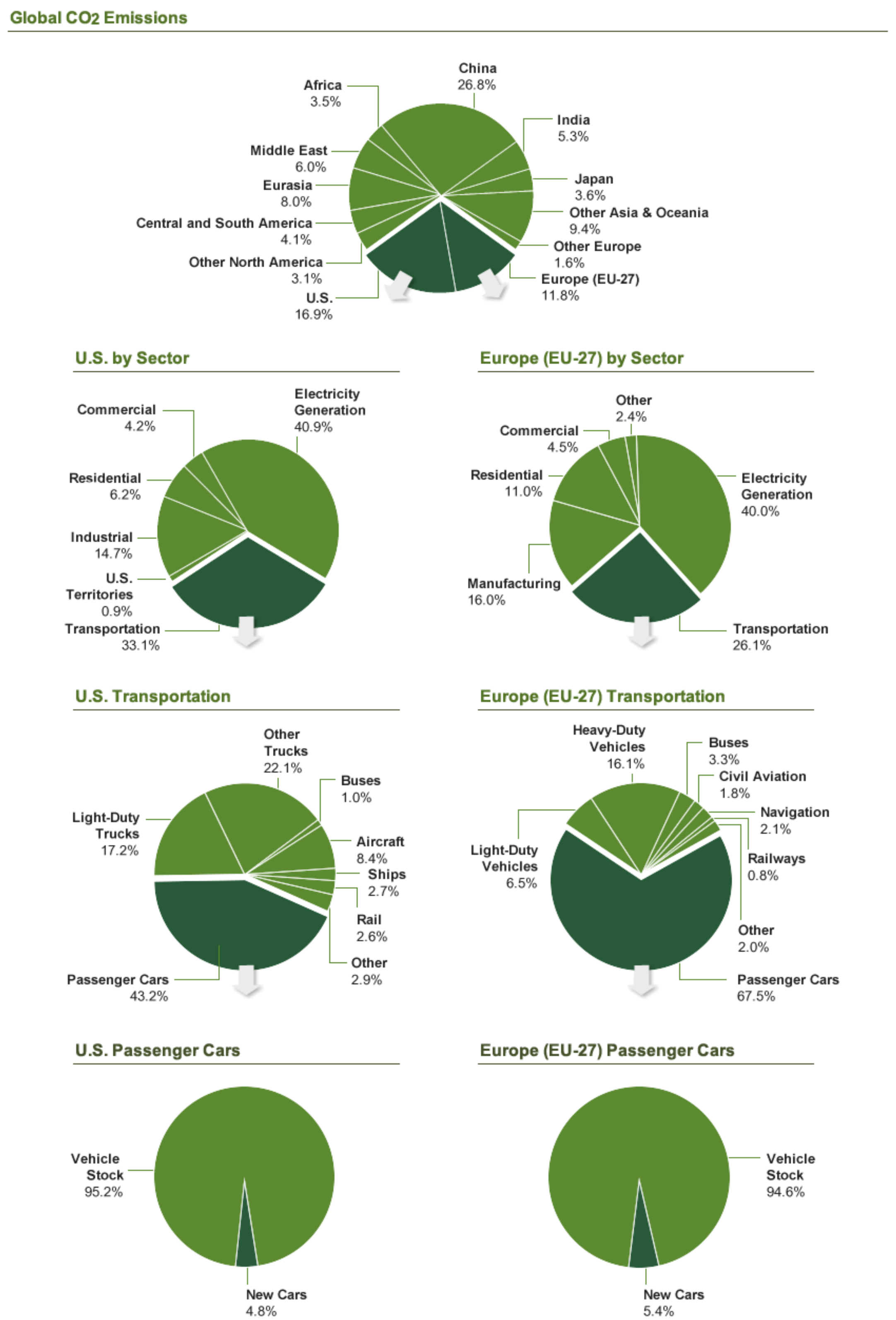
Data source: NASA (2014)

Global Emissions

Figure 3 (below) provides a breakdown of estimated 2011 fossil fuel CO_2 emissions by region. For the U.S. and Europe (EU-27), the emissions are further broken down by sector and by mode in the transportation sector. The data were taken from reports published by the International Energy Agency, the European Environment Agency and the U.S. Environmental Protection Agency. Globally, emissions from cars and light-duty trucks comprise about 11 percent of all fossil fuel CO_2 emissions. In the U.S., cars and light-duty trucks account for approximately 20 percent of fossil fuel CO_2 emissions, or about 3 percent of global fossil fuel CO_2 emissions. In Europe, passenger cars and light-duty vehicles account for approximately 19 percent of fossil fuel CO_2 emissions, or about 2 percent of global fossil fuel CO_2 emissions.

Until approximately 2007, the U.S. was the largest CO_2 emitter. Around 2008, however, emissions from China surpassed those from the U.S. due to China's rapid economic development, and it is expected that the gap between emissions from China and those from the U.S. will continue to widen in the future. Still, per-capita emissions of CO_2 in the U.S. are expected to remain higher (currently by approximately a factor of three) than those in China.

Figure 3: Regional distribution of fossil fuel CO_2 emissions in 2011



Global CO_2 Emissions

Percent

	2011
U.S.	**16.9**
Europe (EU-27)	**11.8**
Other North America	3.1
Central and South America	4.1
Eurasia	8.0
Middle East	6.0
Africa	3.5
China	26.8
India	5.3

Japan	3.6
Other Asia & Oceania	9.4
Other Europe	1.6

U.S. by Sector

Percent

	2011
Transportation	**33.1**
U.S. Territories	0.9
Industrial	14.7
Residential	6.2
Commercial	4.2
Electricity Generation	40.9

Europe (EU-27) by Sector

Percent

	2011
Transportation	**26.1**
Manufacturing	16.0
Residential	11.0
Commercial	4.5
Electricity Generation	40.0
Other	2.4

U.S. Transportation

Percent

	2011
Passenger Cars	**43.2**
Light-Duty Trucks	17.2
Other Trucks	22.1
Buses	1.0
Aircraft	8.4
Ships	2.7
Rail	2.6
Other	2.9

Europe (EU-27) Transportation

Percent

	2011
Passenger Cars	**67.5**
Light-Duty Vehicles	6.5
Heavy-Duty Vehicles	16.1
Buses	3.3
Civil Aviation	1.8
Navigation	2.1
Railways	0.8
Other	2.0

U.S. Passenger Cars

Percent

	2011
Vehicle Stock	95.2
New Cars	4.8

Europe (EU-27) Passenger Cars

Percent

	2011
Vehicle Stock	94.6
New Cars	5.4

Beyond CO_2

While carbon dioxide (CO_2) is by far the most important greenhouse gas associated with the use of motor vehicles, small amounts of other greenhouse gases are also emitted, notably methane (CH_4), nitrous oxide (N_2O) and hydrofluorocarbon-134a (HFC-134a). We take a holistic view of climate change and are addressing non-CO_2 emissions in our research, product development and operations.

Methane and nitrous oxide are combustion products formed in the engine and emitted into the atmosphere. Although the overall contribution of these pollutants is small, manufacturers have had to meet new standards for these emission constituents since 2012. We have assessed the contribution to climate change made by methane emissions from vehicles as about 0.3 to 0.4 percent of that of the CO_2 emissions from vehicles. We have also assessed the contribution to climate change from N_2O emissions from vehicle tailpipe emissions (i.e., not including potential emissions associated with fuel production) as about 1 to 3 percent of that of tailpipe CO_2 emissions. The contribution from HFC-134a is slightly higher. We have estimated that the radiative forcing contribution of HFC-134a leakage from an air-conditioner-equipped vehicle is approximately 3 to 5 percent of that of the CO_2 emitted by the vehicle.[1] When expressed in terms of "CO_2 equivalents," the contribution of vehicle emissions to radiative forcing of climate change is dominated by emissions of CO_2.

We are also addressing other non-CO_2 greenhouse gases such as perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6). Through our Restricted Substance Management Standard we have prohibited SF_6 in magnesium casting. We are continuing our scientific research to determine the relative contribution of a wide range of long-lived greenhouse gases on the radiative forcing of climate change. In 2013, for example, we worked with an international team of climate and atmospheric scientists to assess the global warming potentials of long-lived greenhouse gases. The values we developed were used by the Intergovernmental Panel on Climate Change (IPCC), the leading international organization for the assessment of climate change and related science, in their 2013 report on the physical basis for climate change.[2] And, we have assessed the contribution to climate change made by "criteria emissions" from light-duty vehicles, including hydrocarbons, nitrogen oxides (NOx), particulate matter and carbon monoxide. Given the impressive reductions in criteria emissions enabled by improvements in engine and exhaust after-treatment technology, we believe that these short-lived emission constituents from light-duty vehicles will continue to have a relatively minor influence on climate change in the future.[3] Their contribution will continue to decline even with no additional technological advancements in vehicles, as the existing vehicle fleet, which includes many older vehicles without the most advanced emissions technology, is replaced by new, less-polluting vehicles.[4]

Reducing the Climate and Ozone Impacts of Vehicle Air Conditioning Refrigerants

Chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs) and hydrofluoroolefins (HFOs), which are used as refrigerants in vehicle air conditioning (AC) units, also have warming effects on the atmosphere and contribute to climate change. CFCs, which are commonly known for their negative impact on the Earth's ozone layer, also have the highest global warming potential of these three refrigerants. Ford has been a leader in conducting research on CFC replacements to eliminate their ozone impacts and reduce the overall global warming potential of air conditioning refrigerants.

In the 1980s and early 1990s, all vehicle manufacturers used CFC-12 (CF2Cl2) as the refrigerant in AC units. By the mid-1990s, in response to the Montreal Protocol on Substances that Deplete the Ozone Layer (1987), vehicle manufacturers switched to HFC-134a (CF3CFH2). Hydrofluorocarbons such as HFC-134a contain only hydrogen, fluorine and carbon; they do not contain chlorine and hence do not contribute to stratospheric ozone depletion. HFC-134a also has a shorter atmospheric lifetime and a substantially smaller global warming potential than CFC-12. As shown in Table 1 below, the global warming potential of HFC-134a is 1,370,[5] compared to CFC-12's global warming potential of 10,900.

As seen in Figure 1 below, the lifecycle emissions of CFC-12 from an AC-equipped car in 1990 were approximately 400 g per vehicle[6] – i.e., a CO_2 equivalent radiative forcing impact comparable to that of the CO_2 emitted from the tailpipe of the car. Replacement of CFC-12 with HFC-134a, together with improvements in AC systems, has led to a dramatic (approximately 30-fold) decrease in the climate impact of refrigerant emissions per vehicle for an AC-equipped vehicle. (This can be seen by comparing the two left-hand bars in Figure 1.) We estimate that lifecycle emissions of HFC-134a from vehicles manufactured in 2010 are approximately 100 g per vehicle per year.[7] Looking to the future, based on published assessments,[8] we believe that HFC-134a emissions from a typical light-duty vehicle manufactured in 2017 will be approximately 50 g per vehicle per year, further decreasing in the impact of HFC-134a emissions on a per-vehicle basis by a factor of two (see the third bar in Figure 1).

In the EU, we were required to use compounds with global warming potentials of 150 or less in the AC units for all approvals of new vehicle types by the end of 2012. This requirement extends to all registered vehicles beginning on January 1, 2017. HFC-134a has a global warming potential of 1,370 and it does not meet the new regulation. Hydrofluoroolefins (HFOs) are a class of compounds that are safe for the ozone layer and have very low global warming potential (typically less than 10). Based upon engineering, environmental and safety assessments, many automakers, including Ford, have chosen the compound known as HFO-1234yf (also known as HFC-1234yf or CF3CF=CH2) for use in European vehicles subject to the above-mentioned legislation timing. Research at Ford[9] has established that HFO-1234yf has a global warming potential of less than one[10]. As seen in the right-hand bar of Figure 1 below, by using HFO-1234yf, the AC refrigerant impact on global warming ceases to be discernible. In addition to using new refrigerants, Ford has also implemented new lower-leakage fitting designs in our AC systems, to reduce refrigerant leakage.

In the U.S., the EPA has proposed that HFCs such as HFC-134a should be added to, and regulated as part of, the Montreal Protocol. We do not support the inclusion of HFCs within the Montreal Protocol for the three reasons stated below:

- HFCs do not contribute to the depletion of stratospheric ozone. HFCs should therefore not be included in the Montreal Protocol on Substances that Deplete the Ozone Layer.
- As seen in Figure 1, replacing CFC-12 with HFC-134a has been a major step forward in environmental protection. Retaining the option to use HFC-134a in the future increases our ability to deliver cost-effective solutions for our customers.
- Emissions of CO_2, CH_4 and N_2O, not HFCs, are the main driver of climate change. (HFCs are currently responsible for less than 1 percent of the radiative forcing by long-lived GHGs.) Regulations focused on less than 1 percent of the problem are not very useful. We need to adopt a life cycle perspective and focus on the most cost-effective options. Assessment of cost effectiveness is required before enacting blanket restrictions on HFCs.

Figure 1: Annual In-Use Greenhouse Gas (GHG) Emissions From Typical AC-Equipped Cars in the U.S in 1900, 2010 and 2016 Using Either CFC-12 (in 1990, Left-Hand Bar), HFC-134a (2010 and 2016, Middle Bars), or HFO-1234yf (Right-Hand Bar) Refrigerants.

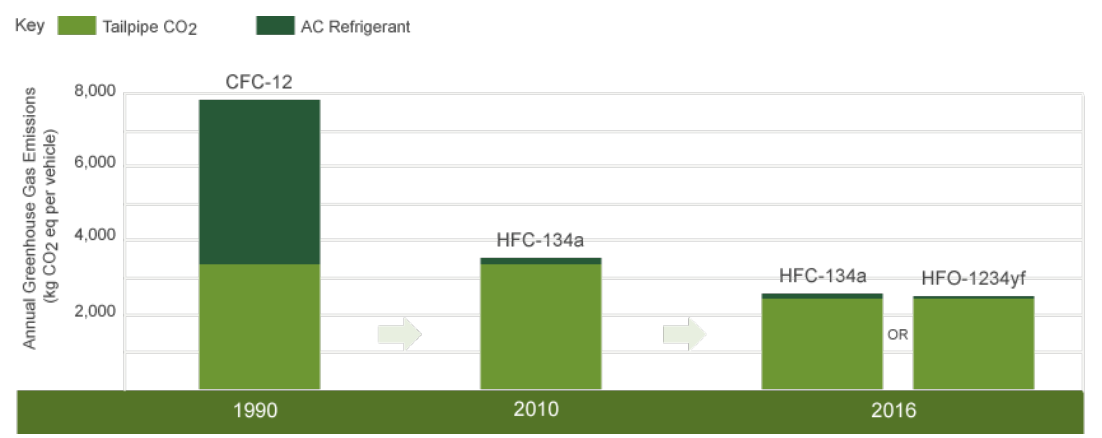


Table 1: Comparison of CFC-12, HFC-134a and HFO-1234yf

Global Warming

Compound	Chemical Formula	Safe for Ozone?	Atmospheric Lifetime[11]	Potential[11]
CFC-12	CF_2Cl_2	No	100 years	10,200
HFC-134a	CF_3CFH_2	Yes	13.4 years	1,300
HFO-1234yf	$CF_3CF=CH_2$	Yes	10.5 days	<1

1. T.J. Wallington, J.L. Sullivan and M.D. Hurley, “Emissions of CO_2, CO, NO_X, HC, PM, HFC-134a, N_2O and CH_4 from the Global Light Duty Vehicle Fleet,” Meteorol. Z. 17, 109 (2008).
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5. World Meteorological Organization, Scientific Assessment of Ozone Depletion: 2010, Geneva (2010).
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8. S. Papasavva, D.J. Luecken, R.L. Waterland, K.N. Taddonio and S.O. Andersen, “Estimated 2017 Refrigerant Emissions of 2,3,3,3-tetrafluoropropene (HFC-1234yf) in the United States Resulting from Automobile Air Conditioning,” Environ. Sci. Technol. 43, 9252 (2009).
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11. O. Hodnebrog, M. Etminan, J.S. Fuglestvedt, G. Marston, G. Myhre, C.J. Nielsen, K.P. Shine, and T.J. Wallington, “Global Warming Potentials and Radiative Efficiencies of Halocarbons and Related Compounds: A Comprehensive Review,” Rev. Geophys., 51, 300–378 (2013). Global Warming Potential (GWP) is a relative measure of how much heat a greenhouse gas traps in the atmosphere. It compares the amount of heat trapped by a certain mass of the gas in question to the amount of heat trapped by a similar mass of carbon dioxide. A GWP is calculated over a specific time interval, commonly 20, 100 or 500 years. GWP is expressed as a factor of carbon dioxide (whose GWP is standardized to 1).

Ford's Greenhouse Gas Emissions

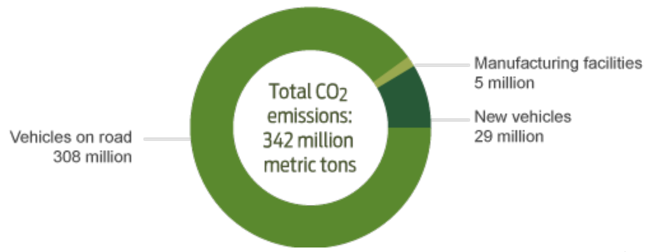
We estimate that annual carbon dioxide (CO_2) emissions from Ford facilities and Ford vehicles driven by our customers are in the range of 300 to 400 million metric tons (Mmt) per year. It is not possible to give a more precise value because of uncertainties in the number of Ford vehicles in the on-road fleet and how many miles these vehicles traveled. The estimate includes emissions from our facilities, emissions from current-year vehicles, and most significantly the emissions from all Ford vehicles more than one year old on the road.

We updated this estimate of global greenhouse gas (GHG) emissions from our facilities and Ford vehicles in 2010, using data from 2008, the most recently available. The estimate is shown in Figure 1.

Please note that while have control over our facility emissions, we have no control over the emissions of vehicles once they are produced and placed in service on the road.

Our assessment of the emissions from Ford's facilities and Ford-made vehicles on the road decreased between 2005 and 2008 from approximately 400 to 350 million metric tons of CO_2, primarily due to better data availability for a key parameter.[1] Normalizing for the change in the key parameter, the emissions remained relatively stable at approximately 350 Mmt. Recognizing the inherent uncertainties in these estimations, we plan to update the assessments approximately every five years. We plan to conduct our next assessment in 2015.

Figure 1: Estimate of CO_2 Emissions from Our Facilities and Vehicles on the Road in 2008



Metric tons

	CO2 emissions
Manufacturing facilities	5 million
New vehicles	29 million
Vehicles on road	308 million
Total	**342 million**

In detail, the updated 2010 snapshot of estimated CO_2[2] emissions shows that, between 2005 and 2008:

- Emissions from our facilities improved by approximately 38 percent. This reflects an approximately 16 percent improvement in the amount of CO_2 emitted per vehicle produced (i.e., our energy-efficiency index improved globally by about 16 percent from 2005 to 2008). It also reflects lower overall vehicle production in 2008. These estimates are fairly precise.[3] Facility GHG emissions, however, are a small percentage (about 2 percent) of the total.
- Emissions from calendar year 2008[4] vehicles on the road decreased by about 22

Related links
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Supplier Greenhouse Gas Emissions

percent relative to the prior year, primarily reflecting a decline in vehicle sales. We have moderate confidence in the precision of the estimate for U.S. vehicles; the estimate for the rest of the world is less precise.[5]

- Emissions from all Ford vehicles on the road were estimated to be about 308 million metric tons of CO_2 per year, lower than in our previous analyses, primarily due to better data availability for a key parameter. This estimate, which accounts for about 90 percent of the total, remains highly uncertain.[6]

Outside the scope of this estimate, we are also in the process of understanding the GHG emissions from our key suppliers' facilities. And, we are expanding our approach to enhance supplier environmental performance beyond more-established supplier environmental performance expectations such as robust environmental management systems (ISO 14001 certification) and responsible materials management. (See the Supplier Greenhouse Gas Emissions section for details of our participation in initial efforts to assess GHG emissions in our supply chain.)

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1. Our estimate for the CO_2 emissions for the greater-than-one-year-old on-road fleet decreased from 370 to 308 Mmt between 2005 and 2008. This decrease primarily reflects better data availability for a key value in the calculation (the global light-duty vehicle fraction of road transportation petroleum use, which we now assume to be 0.6 as opposed to 0.7 in our previous analyses). Using the old data value of 0.7 for the 2008 global CO_2 estimate would increase the 308 Mmt value to 359 Mmt. Such changes in our assessment reflect the difficulties in assessing the emissions precisely from the global fleet of Ford vehicles.
2. CO_2 emissions account for substantially all of the GHG emissions from our facilities and vehicles.
3. This is calculated consistent with the World Resources Institute/World Business Council for Sustainable Development Greenhouse Gas Protocol; it includes direct (Scope 1) and indirect (Scope 2) emissions.
4. 2008 is the most recent year for which complete data are available.
5. Calculated using Ford U.S. Corporate Average Fuel Economy and global market share figures. This estimate is subject to considerable uncertainty as it incorporates multiple assumptions about how consumers use their vehicles (e.g., miles traveled overall and urban/highway breakdown) and about fuel economy values in markets outside of the U.S.
6. This is calculated based on our market share and a sector-based approach to determine the fractional contribution of light-duty vehicles to global total CO_2 emissions. This estimate is subject to considerable uncertainty, as it is based on multiple assumptions, including that all automakers' fleets have the same fuel economy and vehicle life span.

Climate Change Risks and Opportunities

Over the past decade, concerns about climate change, the price of fuel and energy security – along with the global recession – have dramatically changed the automotive business. This creates substantial risks for automakers but also opportunities for innovation that enable growth and expansion. Below we discuss the general trends driving change in our markets and take a closer look at several key markets. We also discuss the physical and supply chain risks to our business posed by climate change.

On this page

- Our Markets
- Physical Risks
- Supply Chain Risks

Our Markets

There is little doubt that the climate change issue has fundamentally reshaped automotive markets around the world. The policy landscape is becoming more complex and interconnected with other market forces. The Climate Change Policy and Partnerships section of this report discusses regulatory developments in detail, but in brief, all of our major markets are increasingly shaped by government actions to regulate fuel economy and carbon dioxide (CO_2) emissions, introduce low-carbon fuels and provide incentives to shift consumer and business behavior. Many governments are also actively involved in promoting the research, development and purchase of new vehicle and battery technologies.

Concerns about fuel prices and price volatility continue to drive a long-term trend toward consumer interest in more fuel-efficient vehicles. In many markets, energy security concerns are also a driver of fuel economy regulation and alternative fuel development, as governments and consumers seek to rely as much as possible on domestic sources of transportation fuel and reduce imports of petroleum products. Recent increases in the production of oil, gas, and biofuels in the U.S. are paving the way for the U.S. to become energy independent in the future.

Investors are showing greater concern about climate change as a material risk for many companies. A variety of voluntary public registries and information services (such as the Carbon Disclosure Project) are providing information to investors about greenhouse gas emissions, while in some countries companies are required to disclose information about their climate risks. Thus, providing climate-change-relevant information to investors and shaping our business strategy with climate change in mind are important elements of maintaining access to capital.

These market shifts are very significant to our company. Everywhere we operate, the financial health of our company depends on our ability to predict market shifts of all kinds and to be ready with the products and services our customers demand.

Our product globalization strategy is designed to help us respond to changing markets and regional preferences, and the risks and opportunities presented by the climate change issue. We have created global vehicle platforms that offer superior fuel economy, safety, quality and customer features. We then tailor each global platform to national or regional preferences and requirements. Our pledge that all our vehicles will offer the best or among the best fuel economy in their segment, coupled with a technology migration plan that is based on the science of climate change, positions us to keep pace with or get ahead of regulatory requirements. New technology is also cutting the time required to bring new vehicles to market, which helps us respond more effectively to the ever-increasing pace of change in our markets.

This approach has helped us take advantage of the market demand for more fuel-efficient vehicles and gain market share. However, the possibility that fuel prices could decline means there is also a risk that consumer preferences will shift back toward less fuel-efficient vehicles.

Please see the Financial Health section for further discussion of our changing markets and how we are responding to them, and the Ford's Climate Change Strategy section for discussion of our strategic response to the risks and opportunities posed by the climate change issue.

Regional Market Trends

North America

New regulations (discussed in the Climate Change Policy and Partnerships section) and concerns about fuel prices, energy security and the impacts of climate change are encouraging the sale of more fuel-efficient vehicles. National surveys in the U.S. continue to show that fuel economy is a key consideration in customers' vehicle purchase decisions. This is echoed by our own customer research and feedback. And, the trend is influencing buyer behavior. In 2006, more fuel efficient vehicles including "sub-compact cars" like the Ford Fiesta, "compact cars" like the Ford Focus, "mid-sized sedans" like the Ford Fusion, and small SUVs like the Ford Escape, made up approximately 39 percent of total industry vehicle sales. While in 2013, sales of these more fuel-efficient vehicles made up just over 52 percent of total industry vehicle sales. However, from 2012 to 2013 consumer demand for more fuel efficient vehicles compared to other vehicles leveled off: the growth of market share of these more fuel efficient vehicles was almost flat from 2012 to 2013 after growing steadily each year since 2009. In addition, over the past decade the use of ethanol in the U.S. gasoline market has increased by a factor of approximately five and there is now widespread availability of E10. With the implementation of the Energy Security and Independence Act of 2007, the trend of increasing renewable fuel use in both gasoline and diesel is likely to continue, and will be limited only by the capability and compatibility of the retail refueling infrastructure to deliver such fuels to the customer, as well as the capability of future vehicles to handle the increased renewable fuel content.

Europe

In Europe, the long-term trend of high-priced fuel and increasing fuel efficiency has continued the market shift toward diesel-powered vehicles, which now make up more than half of all new vehicle sales. This trend is reinforced by sales incentives in some European countries aimed at reducing CO_2 emissions from older, less-efficient vehicles. In addition, downsized gasoline engines like Ford's line-up of EcoBoost® engines are also gaining traction with consumers, and more automakers – including Ford – are offering small, around 1.0 liter and below, direct injection, turbo engines. Several European countries have CO_2-based taxation with aggressive tax break points, which has boosted sales of smaller, more fuel-efficient cars. Tough new CO_2 emission regulations have also come into effect, which will continue to drive fuel-economy improvements in new automobiles. Automakers, including Ford, have begun to introduce and announce plans for hybrid electric, battery electric and plug-in hybrid electric vehicles for the European market.

Asia

The Chinese government is actively promoting vehicle electrification and supporting research in this area, based on its desire to support growth and development, balanced with the need for energy security and a cleaner environment. The Chinese central government currently provides incentives to purchasers of "new energy vehicles" (defined as battery electric and plug-in electric vehicles) that are manufactured in China. However, sales of the new energy vehicles have been consistently under the target set by the central government. The majority of domestic and global automakers are launching or considering launching a range of hybrid electric vehicle technologies in China, including Auto Stop-Start (micro-hybrid) and full hybrid electric vehicles. Some of these technologies are already available in the Chinese market. The majority of new energy vehicles currently available in China are offered by domestic Chinese manufacturers under national Chinese brands.

South America

In Brazil, our largest market in South America, the use of biofuels is widespread, as a result of national policy and consumer preference. All gasoline in Brazil is blended with 20 to 25 percent ethanol, and pure ethanol is also used extensively as a motor fuel. A new regulation, the Automotive Regime, issued in 2012 requires that manufacturers selling vehicles in Brazil meet a minimum 12 percent improvement in industry-wide fuel efficiency by October 2017. A voluntary fuel-economy labeling program is also in place, along with a star ranking program for light vehicles that favors low-emission, low-CO_2, ethanol, flexible-fuel and hybrid vehicles. Consumers tend to choose vehicles with small engines, and approximately 85 percent of new vehicles purchased have flexible-fuel capabilities. Since 2010, Ford has offered the Fusion Hybrid in Brazil.

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Physical Risks

Global climate change raises the potential for shifting patterns of extreme weather and other risks to our facilities.

For insurance purposes, we assess the risks each of our facilities faces (with input from third-party engineers) at least annually. This risk assessment is updated based on new data and takes into account the risk of exposure to hurricanes, tornadoes, other storms, flooding and earthquakes. As a result of this process, we believe we have a good understanding of the physical risks faced by our facilities and how those risks are changing over time.

Extreme weather has the potential to disrupt the production of natural gas, a fuel necessary for the manufacture of vehicles. Supply disruptions raise market rates and jeopardize the consistency of vehicle production. To minimize the risk of production interruptions, Ford has established firm delivery contracts with natural gas suppliers and installed propane tank farms at key manufacturing facilities as a source of backup fuel. Higher utility rates have prompted Ford to revisit and implement energy-efficiency actions that previously did not meet our internal rate of return. Climate change also has the potential to affect the availability and quality of water. We are examining this issue as part of our water strategy.

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Supply Chain Risks

Our suppliers, which are located in more than 60 countries, are subject to market, regulatory and physical risks as a result of greenhouse gas regulation and the impacts of climate change. These risks could affect their competitiveness or ability to operate, creating the potential for disruptions to the flow of supplies to Ford. For example, suppliers may be subject to reporting requirements, fees or taxes, depending on where their operations are located. See the Supply Chain section for a discussion of actions we are taking to better understand the climate risks of our suppliers and to promote a competitive supply chain.

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U.S. Energy Security

For many years, U.S. consumers and politicians have been concerned about energy security, due to the country's continuing dependence on imported foreign oil. These concerns have been based on a trend of increasing consumption of crude oil in the form of gasoline for transportation and increasing crude oil imports in the U.S. since the 1960s (see Figure 1 below). Unlike the utility sector, which has a diverse energy portfolio, light-duty transportation is approximately 95 percent reliant on crude oil. This dominance of crude oil, coupled with the continued reliance on foreign countries for supply, is at the core of the U.S. energy security concerns. Furthermore, instability in the Middle East, one of the world's primary oil-producing regions, as well as the high and volatile price of gasoline in the U.S., also feed these concerns.

However, recent trends in the consumption of crude oil for transportation in the U.S., driven in part by increases in vehicle fuel efficiency, as well as increases in the production of oil in the U.S., suggest that U.S. energy security will become less of an issue in the future. In fact, the International Energy Administration recently released a report that predicts that the U.S. will be the largest global producer of oil by the mid-2020s, and by 2030 will be a net exporter of oil. If this prediction holds true, the U.S., which now imports about 20 percent of its total energy needs, would become energy self-sufficient in the coming decades.[1]

The U.S. marketplace has also seen the widespread penetration of renewable fuel use over the past 10 years, which further reduces U.S. reliance on foreign sources of oil. Today more than 90 percent of the gasoline offered for sale at retail refueling stations contains 10 percent ethanol (E10) by volume. The Energy Independence and Security Act of 2007 mandated increasingly greater volumes of renewable fuel; ethanol is currently the primary renewable fuel of choice. It should be noted that the widespread use of E10 is only possible because the vast majority of public retail refueling stations have dispensing and tank infrastructure that is compatible with E10, and more than 95 percent of the on-road vehicle fleet today is able to operate on gasoline containing 10 percent ethanol. Discussions of the widespread availability of higher blends of ethanol fuel will require further improvements in retail refueling infrastructure and vehicle compatibility.

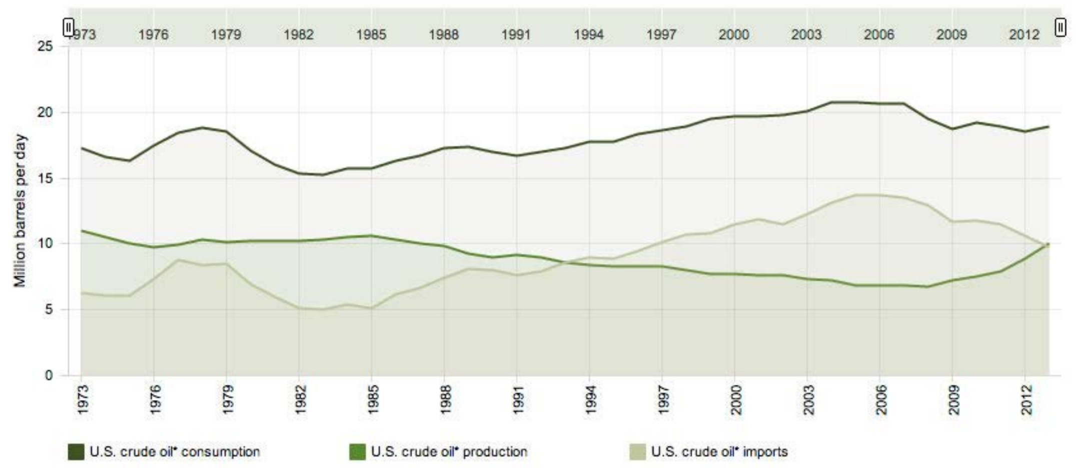
Figure 1 below shows that increases in fuel efficiency over the years have largely compensated for the increase in vehicle miles traveled. Since the 1970s, the fuel efficiency of new passenger cars more than doubled, and fuel economy rates in trucks have increased more than 50 percent. As a result, though vehicle miles traveled increased by a factor of four, gasoline consumption increased by only a little over a factor of two.

Figure 2 shows that U.S. demand for crude oil has declined in recent years. The economic downturn, improvements in vehicle fuel efficiency, and changes in consumer behavior have contributed to this decline.

Nonetheless, for the time being, energy security remains a serious concern in the U.S. and other major markets and it continues to drive demand for more fuel-efficient vehicles.

Figure 1: Total Miles Traveled and Gasoline Consumed

Figure 2: Crude Oil* Consumption, Imports and U.S. Production



* Note: includes crude oil and other petroleum products, including natural gas plant liquids, processing gain, fuel ethanol and biodiesel.

1. International Energy Administration, World Energy Outlook 2012.

Ford's Climate Change Strategy

To respond to the risks and opportunities posed by the climate change issue, our long-term strategy is to contribute to climate stabilization by:

- Continuously reducing the greenhouse gas (GHG) emissions and energy usage of our operations;
- Developing the flexibility and capability to market lower-GHG-emission products, in line with evolving market conditions; and
- Working with industry partners, energy companies, consumer groups and policy makers to establish an effective and predictable market, policy and technological framework for reducing GHG emissions.

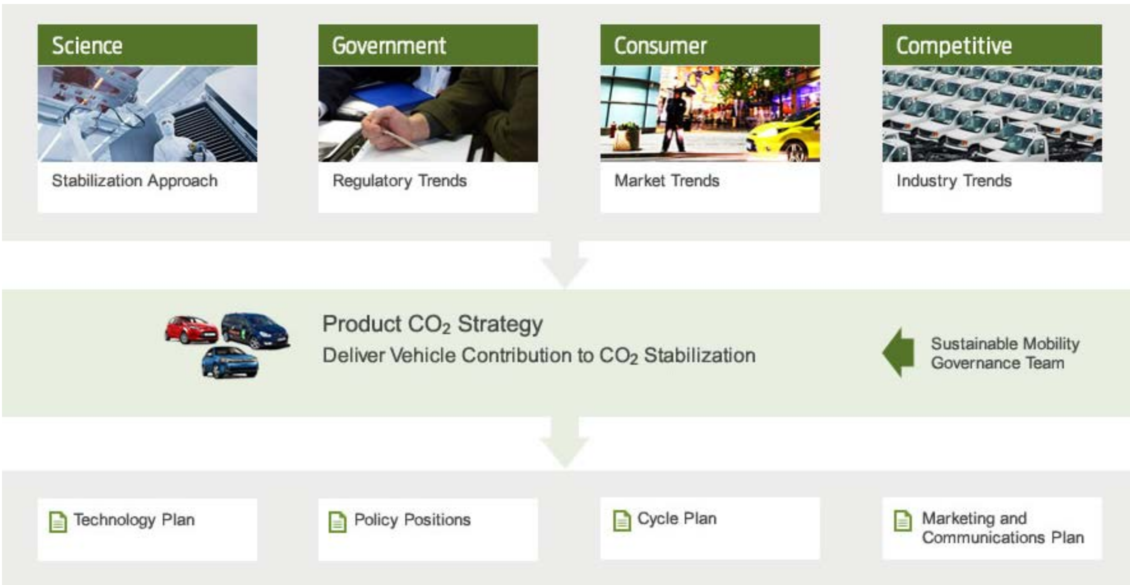
Our product plans in all regions are aligned with our overall goal of contributing to climate stabilization. Our technology and product strategy to meet this goal is based on the modeling of vehicle and fuel contributions to emission reductions and an analysis of market and regulatory trends (see figure below). Our climate change strategy is supported by our sustainable mobility governance, which establishes structures and accountability for implementing the strategy.

Related links

This Report

- Sustainable Technologies and Alternative Fuels Plan
- Vehicle Fuel Efficiency and CO_2 Progress and Performance

Product Sustainability Process



The specifics of our vehicle technology and product strategy to meet this goal are laid out in the Sustainable Technologies and Alternative Fuels Plan, which can be found in the Greening Our Products section of this report. The plan details steps we are taking in the foreseeable future to develop and deploy vehicle and fuel technologies.

We believe this strategy is already showing results by positioning our company to take advantage of opportunities created by shifts in markets. We have implemented all of the near-term actions of our plan, and our commitment to outstanding fuel economy aligns well with consumer interest in fuel-sipping vehicles. For example, from 2009 to 2013, industry sales of more fuel-efficient vehicles including subcompact cars, compact cars, mid-sized sedans, and small SUVs increased by 57 percent. Sales of more fuel efficient vehicles also grew faster than overall industry sales, which grew by 51 percent from 2009 to 2013. Ford's sales of these vehicles increased even more than the industry overall, increasing by 67 percent from 2009 to 2013. However, from 2012 to 2013, industry-wide sales of these more fuel efficient vehicles grew a bit more slowly than overall vehicle sales; they increased by 8 percent, while overall industry sales grew by 9 percent. For the longer term, we are preparing to provide regionally appropriate approaches based on global platforms and advanced vehicle technologies, including electric vehicles, biofuel vehicles and (as fuel and infrastructure become available) hydrogen fuel cell vehicles. In addition, we have conducted dialogues with stakeholders, exploring sustainable mobility projects to demonstrate mobility solutions that meet the needs of urban and rural communities by leveraging information technology to integrate private and public transportation options. Please see the Financial Health section for details on these efforts.

Climate Change Strategic Principles

Our approach to greenhouse gas (GHG) stabilization is aligned around the following key strategic principles:

1. Technical, economic and policy approaches to climate change need to recognize that all carbon dioxide (CO_2) molecules (or GHG equivalents) produced by human activities make the same contribution to climate change. Once those molecules reach the atmosphere, they contribute to the greenhouse effect, regardless of their source. However, the cost of reducing those emissions varies significantly depending on their source, and we should attempt to achieve the most economically efficient solutions possible.
2. The transportation sector represents a closely interdependent system, characterized by the equation: "Vehicle + Fuel + Driver = GHG emissions." Each element in this equation depends on the others. For example, vehicle manufacturers can bring to market flexible-fuel vehicles, but successfully reducing GHG emissions depends on fuel companies providing renewable biofuels, as well as consumer demand for the vehicles and fuels.
3. Future developments in technologies, markets, consumer demand and policies are uncertain. The business strategies that Ford implements, and the public policies that we encourage, must have the flexibility to succeed in a range of potential scenarios.
4. Early affordable steps to reduce GHG emissions from our products and processes may delay the need for drastic and costly reductions later. Lack of agreement on long-term solutions cannot be used as an excuse to avoid near-term actions.

Ford's Science-Based CO_2 Targets

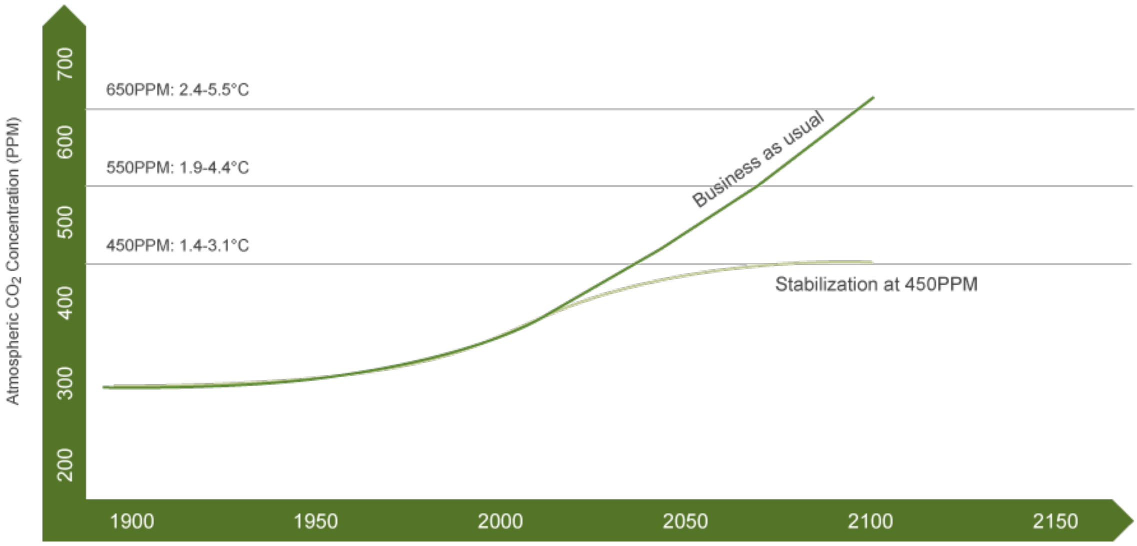
Throughout this report, we refer to Ford's climate goals as "science-based" – specifically, based on the science of climate stabilization. An advantage of this approach is that it gives us an objective, long-term goal focused on an environmental outcome – the stabilization of carbon dioxide (CO_2) in the atmosphere. A disadvantage is that the goal can be difficult to explain and communicate. In this section, we delve into our science-based goal by discussing what stabilization means, how we use "glide paths" to align our product plans with emission reductions, and how our CO_2 model works and how we use it in our planning.

The stabilization-based goal had its start in 2004, when Ford's internal Climate Change Task Force faced a dilemma. After an extensive study, it was clear to the cross-functional group of senior executives that several forces were converging to fundamentally change vehicle markets, especially in North America and Europe. Current and anticipated greenhouse gas and fuel-economy regulation, rising fuel prices and growing consumer awareness of the climate change issue all pointed to a shift in sales toward cars rather than trucks, and toward smaller and more fuel-efficient vehicles. We needed to rapidly reorient our product offerings.

But what should drive new product goals? As a practical matter, the company needed to be able to meet new regulatory mandates, and we needed some way to plan for new products without certainty about future fuel economy regulations. Beyond that imperative, we had taken to heart our responsibility to contribute to meeting the challenge of climate change. So, Task Force members decided to base product planning on the goal of climate stabilization, and they asked Ford's in-house scientists to devise a way to test scenarios for meeting that goal.

Our Stabilization Commitment

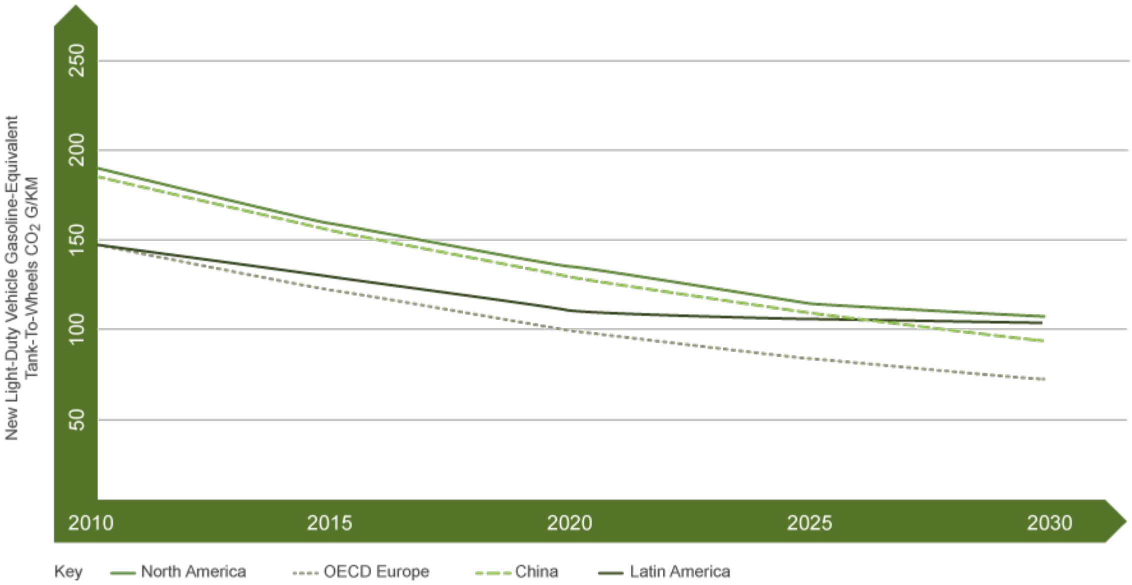
Ford researchers have played a leading role in scientific research to understand and quantify the contribution of vehicles to climate change. We have also worked with a variety of partners to understand current and projected man-made greenhouse gas (GHG) emissions, and the steps that can be taken to reduce them. Many scientists, businesses and governmental agencies have concluded that stabilizing the atmospheric concentration of CO_2 at approximately 450 parts per million (ppm) may help to forestall or substantially delay the most serious consequences of climate change (see chart below).



Ford has committed to doing our share to stabilize atmospheric CO_2 at 450 ppm. Using a science-based CO_2 model (see The "CO_2 Model:" The Science Behind Our Scientific Approach), we have calculated the amount of light-duty vehicle (LDV) CO_2 emissions that are consistent with stabilizing the concentration of CO_2 in the atmosphere at 450 ppm. We then calculated the reductions in the CO_2 emission rate (g/km) from new LDVs needed over the coming decades to achieve 450 ppm atmospheric CO_2, based on projections of vehicle sales and scrappage. Plotting these emission levels over time yields the "CO_2 glide paths" that drive our technology plans.

We have calculated region-specific CO_2 glide paths for North America, Europe, Brazil and China. The glide paths take into account regional differences in vehicle size and fuel consumption, government regulations and biofuel availability. Although the initial (current) CO_2 emissions rate varies considerably by region, to provide the significant emission reductions needed, all regions need to move toward similar targets. For the light-duty vehicle sector to meet the 450 ppm CO_2 emissions limits, all automakers must reduce their LDV emissions by the proportion prescribed by the CO_2 glide paths (see chart below). We have shared our thinking behind the development of these industry-average targets with interested stakeholders and have received positive feedback. We have also published the methodology behind the development of our CO2 glide paths in the peer reviewed scientific literature.[1]

Industry-Average CO_2 Glide Paths[2]



In 2010, we applied the CO_2 glide path methodology to develop CO_2 targets for our commercial vehicles and facilities.

We believe that a science-based approach is the right way forward, and Ford's sustainability plan is based on these science-based emissions targets. We compare the glide paths to competitive and regulatory factors in each region to inform long-term technology plans, and identify opportunities and risks.

In general, our glide paths are consistent with existing and proposed fuel economy and vehicle CO_2 regulations. In the absence of certainty about future regulations, the glide paths provide a good guide for long-term product development planning. The industry North American glide path is generally consistent with existing and proposed U.S. fuel economy regulations through 2025. The Latin American glide path is more stringent than proposed regulations in Brazil. The European region industry glide path is generally consistent with European vehicle CO_2 regulations through 2020 but slightly less stringent than European proposed regulations for 2025. The Asia region glide path is slightly more stringent than vehicle CO_2 regulations proposed by the Chinese government for 2015 and slightly less stringent than Chinese proposed regulations for 2020.

We caution that while our product development plans are based upon delivering long-term reductions in CO_2 emissions from new vehicles that are similar to those shown for the industry-average glide paths, we anticipate that the year-over-year reductions will vary somewhat from the glide paths. In some years the reductions will be greater than those shown in the glide paths and in other years they will be less. That is because delivering on these targets will be dependent to some degree on market forces that we do not fully control (e.g., changes in energy prices and changes in the mix of vehicles demanded by the consumers in the markets in which we operate). Furthermore, our product strategy is based on multiple inputs, including regulatory requirements, competitive actions and technology plans.

We annually review the assumptions and input data in the CO_2 model. Because of the long-term view of the model, we only update the glide paths on a five-year basis. In 2012 we completed the first update since the glide paths were implemented. As part of this review, we assessed our glide path analysis methodology and incorporated new forecasts for vehicle sales and the latest data on the CO_2 intensity of fuels. The adjustments to glide paths based on these changes were minor.

Climate change is a long-term challenge that demands long-term solutions. We believe a philosophy of continuous improvement implemented over the long term is the correct solution to this challenge. Following the CO_2 reductions called for in our glide path assessment is a significant challenge. It is a commitment that we do not undertake lightly. However, we believe that dramatic reductions in CO_2 emissions are required over the long term to forestall or substantially delay the most serious consequences of climate change, and we are committed to doing our part.

Ford's leadership in using climate science to set our CO_2 targets has been recognized externally. In 2012 we received a Goal-Setting Certificate at the U.S. Environmental Protection Agency's Climate Leadership Awards Ceremony and Conference for our global manufacturing CO_2 strategy.

To explore which vehicle and fuel technologies might be most cost-effective in the long-term stabilization of atmospheric CO_2 concentrations, we have worked with colleagues at Chalmers University of Technology in Gothenburg, Sweden. Specifically, we are working together to include a detailed description of light-duty vehicles in a model of global energy use for 2010 to 2100. Several technology cost cases have been considered. We found that variation in vehicle technology costs over reasonable ranges led to large differences in the vehicle technologies utilized to meet future CO_2 stabilization targets. We concluded that, given the large uncertainties in our current knowledge of future vehicle technology costs, it is too early to express any firm opinions about the future cost-effectiveness or optimality of different future fuel and vehicle powertrain technology combinations.[3] This conclusion is reflected in the portfolio of fuel and vehicle technologies that are included in our sustainability strategy. We are continuing to develop the global energy model with researchers at Chalmers. We believe the model will provide valuable insights into cost-effective mobility choices in a future carbon-constrained world.

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1. S. L. Winkler, T. J. Wallington, H. Maas, and H. Hass, Light-Duty Vehicle CO_2 Targets Consistent with 450 ppm CO_2 Stabilization, Environ. Sci. Technol., Light-Duty Vehicle CO_2 Targets Consistent with 450 ppm CO_2 Stabilization (2014).
2. E.U. and China glide paths were developed based on the New European Driving Cycle (NEDC), and North America and Latin America glide paths were developed based on the Federal Test Procedures (FTP), which are the testing requirements used by governments in these regions to assess the emission levels of car engines and/or fuel economy in light duty vehicles.
3. M. Grahn, E. Klampfl, M. Whalen, and T.J. Wallington, "Sustainable Mobility: Using a Global Energy Model to Inform Vehicle Technology Choices in a Decarbonised Economy," Sustainability, 5, 1845–1862 (2013).

The "CO_2 Model": The Science Behind Our Scientific Approach

In 2005, Ford's scientists began development of a global carbon dioxide (CO_2) model. To create it, they modified the Sustainable Mobility Project model (developed by the International Energy Agency) and combined it with global CO_2 emission-reduction pathways for varying levels of atmospheric CO_2 stabilization (as described by the Model for the Assessment of Greenhouse Gas Induced Climate Change, developed by the National Center for Atmospheric Research). The scientists then calculated the CO_2 emission reductions required of new light-duty vehicles up to the year 2050 for a range of CO_2 stabilization levels and different regions of the world, using a simplifying assumption of the same percentage CO_2 emission reductions across all sectors.

At the lower CO_2 stabilization levels, the required emission reductions are extremely challenging and cannot be accomplished using vehicle technology alone. Ford's CO_2 model and other modeling tools combined to explore assumption sensitivities around vehicle technologies, baseline fuels and biofuels.

The CO_2 model is not intended to provide "the answer," but rather a range of possible vehicle and fuel solutions that contribute to a pathway to CO_2 reductions and, eventually, climate stabilization. Our Blueprint for Sustainability – and the technology and product actions it spells out – is based on options developed through this modeling exercise.

The model and its results have been a centerpiece of discussions with a variety of stakeholders. Below are some of the questions that have been raised through these discussions, and the answers to them.

How does the model account for emissions growth or reduction in developing countries?

We recognize that developing countries generally have relatively low per-capita energy use but high rates of emissions growth, reflecting growing economies. The CO_2 model uses a science-based approach that allows for growth in developing countries, to derive CO_2 reduction targets for light-duty vehicles consistent with a 450 ppm CO_2 stabilization pathway.

Since fuel use is the dominant cause of CO_2 emissions, how does the model account for projected changes in the carbon footprint of automotive fuels?

Ford has studied multiple scenarios in which the auto industry and the energy industry work together to reduce overall well-to-wheels CO_2 emissions from the light-duty transportation sector. These joint strategy scenarios (see Figure 1 below) allow us to develop a least-cost vehicle technology road map. For the carbon footprint of fuels, we rely on the well-to-tank CO_2 emissions for different alternative fuels estimated by different region-based models, including the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model for North America, and the EUCAR/JRC/CONCAWE analysis for Europe.

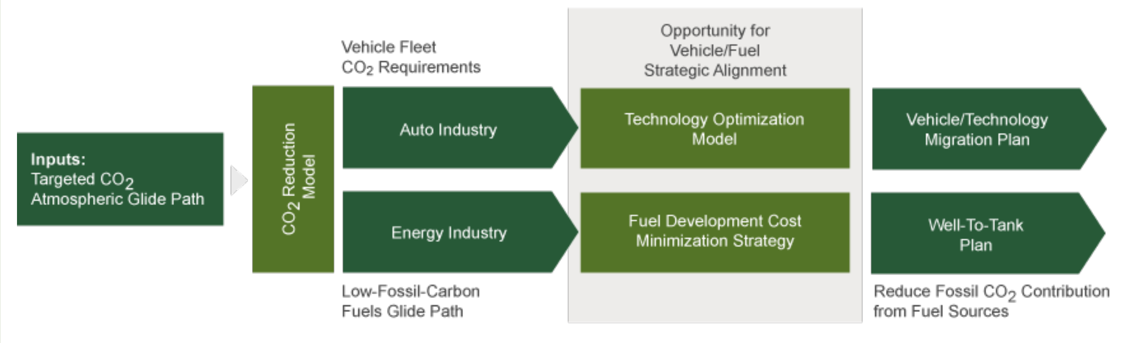
Are you continuing to test alternative scenarios?

In the long run, the roles of consumers, governments and fuel availability will be pivotal in dictating actual CO_2 emission reductions, and Ford continues to take them into consideration in fine-tuning a truly viable and sustainable CO_2 stabilization pathway.

How does the model consider the cost of technologies and alternative fuels?

In a separate study (and as discussed on the Ford's Science-Based CO_2 Targets page), Ford and our partner Chalmers University of Technology have developed a global energy model that looks into minimal-cost scenarios across different sectors and explores assumption sensitivities around vehicle technologies, fuel technologies, connections between the different energy sectors, and biofuels. The model provides information on the combinations of options that will yield the necessary emissions reductions at an affordable cost to consumers. We have used this model to develop scenarios to assess the global lowest-cost vehicle and fuel technology solutions consistent with CO_2 stabilization.

Figure 1: Ford's Sustainability Framework and Technology Migration Development



Climate Change Policy and Partnerships

Ford and the automotive industry as a whole have an important role to play in achieving climate stabilization. We take this responsibility seriously, and have based our global approach to product planning and policy participation on the science of climate stabilization, doing our part to reduce emissions significantly in order to maintain atmospheric concentrations of greenhouse gas emissions at or below 450 ppm. We accept that simply "not getting worse" is not good enough. We are committed to working with all key stakeholders to promote climate change policy that helps to match vehicle technology, fuel technology and availability, and consumer demand to effectively reduce transportation sector emissions and reach climate stabilization goals. We welcome, and have worked to promote, comprehensive market-based policy approaches that will provide a coherent and effective framework for GHG emission reductions and give companies a clear understanding of their role in achieving reductions.

Clarity and consistency of fuel economy and vehicle GHG regulations is critical to our ability to plan, develop and implement new products. These regulations effectively regulate what vehicles we are allowed to build and sell.

However, light-duty trucks and passenger vehicles represent only about 11 percent of all global fossil fuel CO_2 emissions, so our industry alone cannot achieve climate stabilization. It will require major efforts by industries, government, and consumers. Even reducing the transportation sector's contribution to climate change cannot be done by automakers alone. It will require partnership of all stakeholders, including automakers, the fuel industry, government and consumers, because effectively reducing emissions will require not only improving vehicle fuel economy, but also developing lower-carbon fuels, infrastructure to deliver those fuels, and government actions to encourage consumers to purchase these more fuel-efficient vehicles and lower-carbon fuels.

In 2012 in the U.S., the Environmental Protection Agency (EPA) and the National Highway Traffic Safety Administration (NHTSA) finalized regulations on a national approach to vehicle greenhouse gas and fuel economy standards for 2017 to 2025. Globally, however, growing budget deficits at national and regional levels have overshadowed climate policy discussions over the last several years.

In our major markets, the regulation of fuel economy and/or vehicle CO_2 emissions is becoming increasingly complex. In addition to competing federal and regional regulations, governments are taking diverse approaches to incentives for emission reductions through rebates, fees, "feebates," privileges for low-emitting vehicles and penalties for high-emitting vehicles. At the same time, some state governments are introducing registration taxes on the same advanced vehicle technologies that assist in CO_2 reductions, to make up for the loss in tax revenues resulting from these vehicles' reduced use of conventional fuels. This very complex policy environment is one important driver of our strategy to develop fuel-efficient and advanced-technology platforms that can be shared globally and tailored to the needs of our customers. Customer vehicle-purchasing choices are affected by vehicle incentives, fuel costs, annual registration costs as well as overall maintenance and ownership costs.

We hope that the information that follows helps to illustrate the diverse array of GHG and fuel economy regulations and incentives that are now shaping our markets. This section provides more detail on developments and Ford's involvement in:

- U.S. policy
- Climate change legislation
- Greenhouse gas and fuel economy regulation

- European policy
- Canadian policy
- Asia Pacific policy
- South American policy
- Renewable fuels policy
- Partnerships and collaboration
- Emissions trading

The map below provides a summary of the existing and proposed CO_2 emission and fuel consumption requirements and standards that vehicle manufacturers face across the globe. For each country the primary metric used in the regulation is listed, such as miles per gallon or grams of CO_2 per mile, as well as the "drive cycle" or vehicle testing process required to calculate compliance with the requirement. The map illustrates that many countries have existing or proposed CO_2 or fuel consumption requirements and that these requirements vary considerably by country and region.

Summary of Global Fuel Economy and Emissions Regulations

Fuel Economy and Emissions Testing Cycle Used

1. U.S. EPA g CO_2/mi
2. U.S. EPA g CO_2/mi and mpg
3. Mexico, South Korea: U.S. EPA g CO_2/km, km/L
4. Brazil: U.S. EPA MJ/km, km/L
5. EU, India, South Africa, Australia: NEDC g CO_2/km
6. China: NEDC L/100 km
7. Taiwan: U.S. EPA or NEDC g CO_2/km
8. Japan: JC08 km/L

Key to map acronyms:

Cycles = vehicle testing procedures required to calculate compliance with a standard

- US EPA = United States Environmental Protection Agency
- NEDC = New European Driving Cycle
- JC08 = current Japanese fuel economy test cycle

Metrics = unit of measurement by which fuel economy or CO_2 requirement is measured

- g CO_2/km = grams CO_2 per kilometer
- km/L = kilometer per liter of fuel
- MJ/km = megajoules per kilometer
- mpg = miles per gallon

U.S. Policy

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- Climate Change Legislation
- Greenhouse Gas and Fuel Economy Regulation

Climate Change Legislation

In the U.S., the policy debate surrounding climate change has been overshadowed by other issues, including concerns over budget deficits. Nevertheless, the U.S. Environmental Protection Agency (EPA) regulates greenhouse gas (GHG) emissions for mobile sources using their authority under the Clean Air Act, while the U.S. National Highway Transportation Safety Administration (NHTSA) has regulated motor vehicle fuel economy since the 1970s. In 2012, the EPA and NHTSA finalized joint greenhouse gas emission and fuel economy regulations for 2017 to 2025 model year light-duty vehicles. These regulations, which continue the "One National Program" approach, are discussed below under Greenhouse Gas and Fuel Economy Regulation.

Ford has participated in the public discourse on broad-based, national climate policy for some time. In 1999, for example, we discussed greenhouse gases in our first corporate citizenship report. In 2000, we were the first automaker to publically acknowledge the issue. In late 2005, we published a special report on the Business Impact of Climate Change, and in 2007 we joined the U.S. Climate Action Partnership (USCAP) to support the prompt enactment of national climate legislation. Because the USCAP organization has been dormant for more than a year, and this policy issue is now not expected to be taken up legislatively in the U.S., we asked to be delisted as a member of USCAP. We nonetheless remain committed to improving fuel economy and reducing greenhouse gas emissions, as evidenced by our support for the One National Program approach to fuel economy regulations discussed below.

These experiences, as well as our participation in carbon markets globally, have helped to shape Ford's position on climate policy. The linked issues of climate change and energy security create an urgent need to transform the country's economy into one with lower greenhouse gas emissions, higher energy efficiency, and less dependence on fossil fuels and foreign oil. This transformation will require changes in all sectors of the economy and society. A comprehensive legislative framework is needed to spur these changes.

The auto industry has supported the rules proposed by EPA and NHTSA, but regulations focusing on just one sector of the economy will not enable us to achieve the necessary level of GHG reductions. We believe we need a comprehensive, market-based approach to reducing GHG emissions if the U.S. is going to reduce emissions at the lowest cost per ton. An economy-wide program would provide flexibility to regulated entities while allowing market mechanisms to determine where GHG reductions can be achieved at the lowest cost. The environment doesn't care where reductions occur, but the economy does, and given the potentially high cost of abatement, it is important to achieve the greatest reductions at the lowest cost possible.

As part of an integrated approach to addressing energy security and climate change, Ford supports comprehensive legislation that will create a price signal to encourage consumers to purchase more fuel-efficient vehicles and engage in other climate-friendly behaviors. Thoughtful and comprehensive national energy and climate policy that provides a price signal is needed to support the billions of dollars being invested in low-carbon and fuel-efficient vehicle technologies. Without a cohesive policy that includes a price signal, we could be caught in an endless cycle wherein development of the advanced technologies needed to help address climate change and energy security is sporadic and not aligned with fuel providers or consumer demand.

Related links

External Websites

- National Highway Traffic Safety Administration
- U.S. Environmental Protection Agency Fuel Economy

Ford will continue to advocate for effective climate change policies that drive down GHG emissions and provide a framework for sound business and product planning.

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Greenhouse Gas and Fuel Economy Regulation

In July 2011, the Obama Administration announced that the state of California, the auto industry and other stakeholders had committed to support a single national program for motor vehicle fuel economy and greenhouse gas standards covering the 2017 to 2025 model years. This is an extension of the “One National Program” regulations that have already been put in place for the 2012 to 2016 model years. Ford views the continuation of the One National Program agreement as a positive step for all stakeholders toward our common goals of energy security and reduced greenhouse gas emissions.

In 2012, the EPA and NHTSA finalized regulations extending the One National Program framework through the 2025 model year. The new rules require manufacturers to achieve, across the industry, a light-duty fleet average fuel economy of approximately 45 mpg by the 2021 model year, and approximately 54.5 mpg by the 2025 model year, assuming all of the carbon dioxide (CO_2) emissions reductions are achieved through the deployment of fuel economy technology. This represents a reduction of roughly 5 percent per year in CO_2 emissions from passenger cars for the 2017 to 2025 model years. For light trucks, the proposed standards represent a reduction in CO_2 emissions of about 3.5 percent per year for model years 2017 to 2021, and about 5 percent per year for model years 2022 to 2025.

It is important to note that the EPA’s 2022 to 2025 GHG standards are final rules; in contrast, NHTSA’s 2022 to 2025 Corporate Average Fuel Economy (CAFE) standards are conditional because, by statute, NHTSA may only set CAFE standards for up to five model years at a time.

Under the rules, each manufacturer’s specific task depends on the mix of vehicles it sells. The rules include the opportunity for manufacturers to earn credits for technologies that achieve real-world CO_2 reductions, and for fuel-economy improvements that are not captured by EPA fuel-economy test procedures. Manufacturers also can earn credits for GHG reductions not specifically tied to fuel economy, such as improvements in air conditioning systems. The rules specify a midterm evaluation process under which, by 2018, the EPA will reevaluate its standards for model years 2022 to 2025 to ensure that those standards are feasible and optimal in light of intervening events. In parallel, NHTSA will undertake a process to promulgate final CAFE standards for those model years. In California, the California Air Resources Board has modified its GHG regulations so that complying with the federal program also satisfies compliance with California’s requirements for the 2017 to 2025 model years.

Ford plans to participate in the midterm evaluation process. For the longer term, Ford supports a legislative solution codifying the One National Program approach beyond 2025, to head off the possibility that various agencies may promulgate and enforce multiple, inconsistent fuel economy and/or GHG regulations in the future.

A national program is essential for the efficient regulation of motor vehicle fuel economy and GHG emissions. It allows manufacturers to average the fuel economy and CO_2 emissions of their vehicles based on nationwide sales, which in turn enables manufacturers to formulate their product plans on a national level to achieve the necessary scale for future technology introductions. In contrast, state-by-state or regional regulations could force manufacturers to restrict the sale of some products in certain parts of the country, harming both consumers and dealers in those areas. Since CO_2 emissions do not create localized air-quality problems, state or regional standards are unnecessary, and would create hurdles, added costs and market disruptions in our path toward achieving reductions.

We intend to work closely with the EPA, NHTSA and other key stakeholders, including California, throughout the midterm evaluation process to ensure continued alignment between our shared goals for the environment and market realities of consumer acceptance of new advanced technologies.

U.S. Heavy-Duty Vehicle Fuel Economy Regulations

In 2011, the EPA and NHTSA promulgated final regulations imposing, for the first time, GHG and fuel economy standards on heavy-duty vehicles (generally, vehicles over 8,500 pounds gross vehicle weight rating). These initial regulations cover the 2014 to 2018 model years for heavy-duty trucks, buses and vans. These regulations cut emissions by improving the fleet’s fuel efficiency by 9 percent to 23 percent, depending on the size of vehicle. The federal government estimates that these standards will reduce GHG emissions by approximately 270 million metric tons. In

Ford’s case, the standards primarily affect our heavy-duty pickup trucks and vans, plus vocational vehicles such as shuttle buses and delivery trucks. In February 2014, President Obama announced that the EPA and NHTSA will issue a new round of standards for these vehicles covering the 2019 model year and beyond. These regulations are expected to be finalized by the spring of 2016.

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European Policy

The European Union has set mandatory carbon dioxide (CO_2) targets for both cars and light commercial vehicles. The specific target for an automaker depends on the average weight of the automaker's vehicles registered in a given year; lower average vehicle weight results in stricter CO_2 targets for a given automaker. Ford cars registered in the EU have relatively low average weight compared to other automakers, which results in stricter targets for Ford compared to the overall industry target of 130 g/km during the 2012 to 2015 period. This target is set to decrease to 95 g/km in the 2020 to 2021 timeframe.

The EU has also established significant regulations about other items related to climate change, such as fuels (including bio-blending), tires and gear-shift indicators, as well as requirements related to fuel economy indicators and more efficient, low-CO_2 mobile air conditioning systems. The EU Commission, Council and Parliament also approved a target for commercial light-duty vehicles to be at an industry average of 175 g/km (with phase-in from 2014 to 2017) and 147 g/km in 2020. In fact, automobiles are one of the most regulated products in the EU, with requirements also covering non-CO_2 emissions, drive-by noise, recycling, substances, electromagnetic requirements, safety, technical aspects and more. Ford is complying and will continue to comply with all these various targets and prohibitions with appropriate product offerings.

In general, Ford is requesting that regulations and policies be well coordinated and not contradictory to each other, and that they also be technology-neutral, be proportional, avoid double regulation, offer sufficient lead time to adjust development and production cycles, and follow an integrated approach in which all stakeholders (industry, infrastructure, consumers and governments) contribute to the solution. Also, any CO_2 regulations should be in line with meeting the global CO_2 target of 450 ppm.

In several EU member states, CO_2 taxation is in place to encourage the early introduction of low-CO_2 vehicles. The major tax break points are often around 50 g/km, 95 to 100 g/km, and 120 g/km, with very high taxation in some countries above these levels. Unfortunately, these tax break points are not harmonized among the European countries.

The industry will continue to invest heavily in research and development, and new product programs in order to reach short-term CO_2 targets. The long-term target will require technological breakthroughs, new refueling infrastructure and a swift renewal of the car fleet on Europe's roads.

Canadian Policy

In September 2010, Environment Canada finalized greenhouse gas emissions regulations for 2011–2016 model year passenger automobiles and light trucks. This regulation aligns emission standards and test procedures with those of the U.S. The regulation provides companies with similar compliance flexibilities to those available under the U.S. Environmental Protection Agency's greenhouse gas (GHG) regulation, including advanced technology credits, air conditioning leakage and efficiency credits, flexible-fuel vehicle credits and credit transfer among fleets. The Canadian federal government is also expected to publish a final regulation in 2014 for light-duty vehicles that maintains alignment with EPA vehicle GHG standards for the 2017 to 2025 model years.

In February 2013, Environment Canada published the final regulation for 2014 to 2018 heavy-duty vehicles. It is also in alignment with the U.S. federal heavy-duty vehicle GHG regulations, which will begin with the 2014 model year. The Provinces of Quebec, Manitoba and British Columbia participate in the Western Climate Change Initiative and had committed to adopt GHG regulations based on California standards. Quebec has promulgated a GHG regulation based on the California standards, but with fewer flexibility mechanisms. Now that the Canadian federal regulation is in place, the Quebec government has amended the Quebec regulation to recognize equivalency with the federal standards. Reporting of Quebec fleet performance is still required. We are hopeful that Quebec will see the benefit of a single standard for Canada, consistent with the One National Program effort in the U.S. Ford has participated in regulatory discussions on this issue, providing technical expertise and supporting a tough, aligned, national standard. British Columbia and Manitoba have both acknowledged the value of the new federal standards.

Environment Canada has also regulated renewable fuel content in on-road gasoline. Effective September 2010, renewable levels in the national pool of gasoline must average 5 percent. Environment Canada has also implemented a regulation for renewable content in diesel fuel. As of July 2011, the regulation requires 2 percent renewable content in diesel fuels.

Asia Pacific Policy

In Ford's Asia Pacific region, sales in China are growing rapidly. Economic growth is a key priority of the Chinese government, to be balanced with energy security and the resolution of air pollution concerns.

The Chinese Ministry of Industry and Information Technology (MIIT) enforced the Stage III fuel consumption Monitoring & Reporting rule beginning July 1, 2012. We are on track to comply with this requirement through 2015. The China Automotive Technology and Research Center (CATARC) is developing Stage IV fuel-consumption targets for the Ministry, which are expected to be completed in 2014 and enforced in the 2016 to 2020 timeframe.

The Chinese government provides limited incentives for the purchase of "new energy vehicles" (including plug-in electric vehicles) made in China. The Chinese government also provides incentives of RMB60K (˜$9,700) per vehicle to customers who purchase plug-in or pure electric vehicle models approved as new energy vehicles.

India, Japan, South Korea, Taiwan, and Vietnam have released new or modified fuel-economy limits, while Hong Kong, Japan, South Korea and Thailand have set or are developing complementary tax incentives based on fuel economy and carbon dioxide targets.

Ford is actively involved in dialogues with governments across Asia Pacific in a number of areas, including sustainable mobility, energy security and environmental protection.

South American Policy

In Brazil, our largest South American market, the large scale use of biofuels is a national policy. All gasoline is blended with 20 to 25 percent ethanol, and pure ethanol is extensively used as motor fuel. Most new vehicles are flexible-fuel vehicles, which are designed to accommodate fuel containing a range of ethanol content. Also, a minimum of 5 percent biodiesel must be added to diesel.

Brazilian emission requirements are periodically updated through an emissions-control program. Brazil also introduced a voluntary vehicle energy-efficiency labeling program; the labels indicate fuel consumption rates for light-duty vehicles with a spark-ignition engine. While the program is voluntary, Brazil also published a new automotive regime that requires participation in the fuel-economy labeling program with improved fuel consumption starting on October 1, 2016. Failure to achieve an absolute target for "corporate energy efficiency" as a function of "fleet corporate average mass" will result in a substantial tax increase and cumulative fines on all automotive domestic sales (local production and imports) retroactive as of January 2013. Additional tax reductions are available if further fuel-efficiency improvements are achieved. A star ranking for light vehicles was also recently introduced, favoring low-emission, low-carbon-dioxide (CO_2), ethanol, flexible-fuel and hybrid vehicles. Diesel use in light vehicles under a one-ton payload is not allowed in Brazil, except for combined-usage vehicles with special off-road characteristics. Ten Brazilian states have issued vehicle pollution control plans and are taking actions to implement in-use vehicle inspection and maintenance programs. Brazil also phased-out S-1800 diesel fuel and now only markets S-10 and S-500; also, sulfur content in gasoline has been lowered to 50 ppm maximum.

In 2013, most of Ford's light-duty products in Brazil were offered as ethanol flexible-fuel vehicles. The new Ford Focus introduced in Brazil in 2013 is the world's first direct-injection flexible-fuel engine. We also provide light- and heavy-duty vehicles that meet biodiesel requirements.

Other South American countries, such as Argentina and Colombia, have significantly increased the use of biofuels. And in 2013, Chile introduced requirements that the fuel-consumption and CO_2-emissions levels of light-duty vehicles be posted at sales locations and in owners' manuals.

Middle East and Africa Policy

Ford has a strong heritage in the Middle East and Africa, with more than six decades of presence in the region. The company has increased sales of the Ford and Lincoln brands in the region significantly in the past four years and we see it as poised to become one of the next big automotive growth markets. However, the region is comprised of diverse markets with different political, cultural and economic environments. While fuel economy and CO_2 have not been key political or consumer priorities in many of the markets in this region to date, the products we have sold in the region have generally benefited from fuel economy and CO_2 improvements we have implemented for products in other regions. We anticipate that new regulatory challenges and opportunities are likely to emerge in the near future.

South Africa has been in the lead in developing standards to reduce vehicle CO_2 emissions. They have enforced a tax based on the car's emissions levels since 2010.

Saudi Arabia has recently been focusing on fuel-efficiency improvements in their vehicle fleet. Requirements for vehicle labeling and reporting in the region are under discussion. They are also considering requirements for potential average fuel consumption fleet targets in the near future. We continue to maintain dialogue with the Kingdom of Saudi Arabia, and our other local markets, to ensure our product strategies complement and align with their national goals.

Renewable Fuels Policy

Today, more than 80 percent of global oil reserves are limited to 10 countries, while biofuels made from sugarcane can be produced in more than 100 countries. First-generation biofuels are playing an important role in building consumer awareness and spurring capital investment in infrastructure and facilities that can be used for more promising second-generation biofuels.

In the U.S., Ford is among the leaders in providing vehicles that can operate on biofuels, and we will continue to produce vehicles capable of operating on biofuels in line with consumer demand and retail refueling infrastructure development. Our flexible-fuel products, which we are delivering at no additional cost to consumers, go well beyond requirements and what most other automakers are doing.

Ford's vision for sustainable biofuels is for accelerated use of renewable fuels to deliver increased energy security, enhance economic development and help to address climate change. This vision includes rapidly expanding the number of vehicles that can operate on biofuels in some regions, increasing the number of stations offering biofuels, developing the fuel distribution network to support customer choice and value, and achieving technology breakthroughs to commercialize advanced biofuels.

Policies in several regions are aimed at increasing the use and availability of biofuels. The U.S. adopted a Renewable Fuel Standard requiring 36 billion gallons of biofuels by 2022, including more than 20 billion gallons of low-carbon advanced biofuels. The EU Renewable Energy Directive has established a 10 percent renewable energy target for transportation energy in 2020, including the use of renewable-based electricity. The EU is also adding more-specific criteria regarding the types of sustainable biofuels that can be counted toward this regulation, and is aiming to limit the amount of crop-based biofuels used to meet the standard. Brazil has had a very aggressive domestic ethanol program for years.

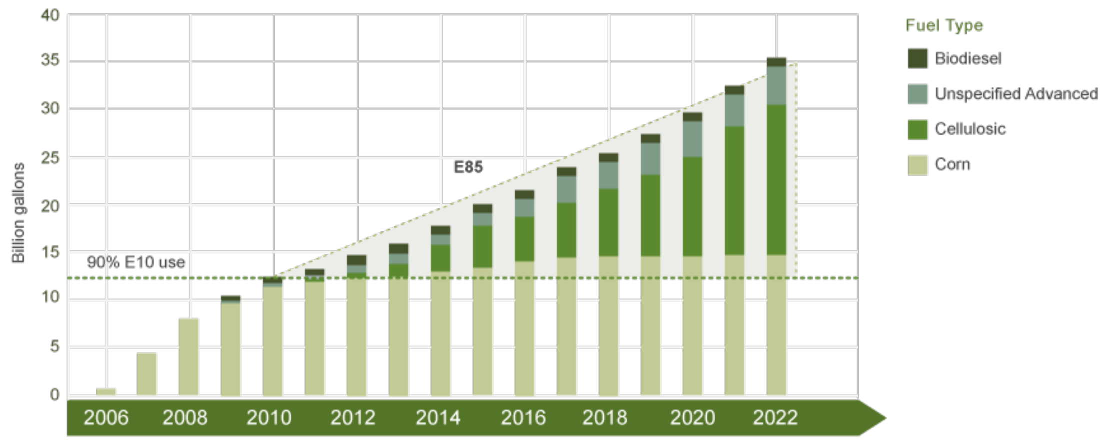
But these policies aren't enough. Providing value and refueling accessibility is critical to engage consumers and get them to use alternative energy sources. Hundreds of millions of vehicles in operation today were designed to use ethanol blends containing less than 10 percent ethanol, and our transportation energy infrastructure was set up to deliver petroleum-based fuels rather than high-concentration alcohols.

In January 2011, the U.S. Environmental Protection Agency (EPA) approved a waiver allowing the use of E15 (a blend of 85 percent gasoline and 15 percent ethanol) in 2001 and later model year vehicles, after previously issuing a waiver allowing E15 to be used in 2007 and later vehicles. Ford's owner manuals are the source for our consumers to identify recommended fuels for use in their particular vehicle. As of the 2013 model year, Ford vehicles are capable of using E15, while prior model years are limited to E10.

On the one hand, we recognize the potential benefits of expanded use of E15 fuel in helping to build markets for renewable fuels in some countries. In addition, since ethanol has an octane rating greater than today's gasoline, blends with higher levels of ethanol have the potential to produce a higher octane fuel, which can enable further improvements in engine efficiency. On the other hand, the implementation of the EPA's E15 waiver presents a number of concerns. In particular, customers should be advised to consult their owner guides, as the use of E15 in vehicles not designed for it has the potential to create problems and void warranties. There is also a need to develop a robust program of regulation to prevent the "misfueling" of older vehicles not authorized by EPA to use E15. We are concerned that the operation of such vehicles on E15 will result in various quality, durability and performance problems, leading to customer dissatisfaction.

In Europe, we recommend that biofuel use be harmonized throughout the region by targeting the introduction of B7 and E10 as standard fuels.

U.S. Renewable Fuel Standard



Partnerships and Collaboration

Addressing the linked issues of climate change and energy security requires an integrated approach – a partnership of all stakeholders, including the automotive industry, the fuel industry, other industries and enterprises, governments and consumers. It will also require the best collective thinking and collaboration from all of these sectors.

Ford is involved in numerous partnerships and alliances with universities, coalitions, nongovernmental organizations and other companies to improve our understanding of climate change. For example, Ford is:

- A charter member of the Sustainable Transportation Energy Pathways Program at the Institute of Transportation Studies at the University of California at Davis. The Institute aims to compare the societal and technical benefits of alternative sustainable fuel pathways.
- Industry co-chair of the U.S. DRIVE Cradle-to-Grave life cycle assessment of energy use, carbon dioxide (CO_2) and greenhouse gas emissions.

Our participation in these and other partnerships helps us to formulate improved strategies for products and policies that will in turn help to address climate change and energy security. The following are links to the above-mentioned organizations and others with which we cooperate on climate change issues:

- 25x'25 (Energy Future Coalition)
- BP
- Center for Clean Air Policy's Climate Policy Initiative
- Clean Fuels Development Coalition
- Diesel Technology Forum
- Governors' Biofuels Coalition
- Harvard University, Belfer Center for Science and International Affairs
- Growth Energy
- My Energi Lifestyle
- University of California at Davis, Institute of Transportation Studies, Sustainable Transportation Energy Pathways Program
- U.S. DRIVE
- World Business Council for Sustainable Development
- World Resources Institute
- World Economic Forum

Emissions Trading

Emissions trading is a key tool in both voluntary and mandatory greenhouse gas (GHG) emissions-reduction programs. Ford was an early participant in carbon markets, with a goal of gaining experience that will be valuable in an increasingly carbon-constrained world.

For example, Ford, along with 11 other companies and the city of Chicago, founded the Chicago Climate Exchange (CCX) in 2003. The CCX was a GHG emissions-reduction and trading program for emission sources and projects in North America. It was a self-regulated, rules-based exchange designed and governed by CCX members. Ford was the first and only auto manufacturing participant in the Exchange. Through the CCX, we committed to reducing our North American facility emissions by 6 percent between 2000 and 2010, and we exceeded that reduction target. The CCX elected to end the emissions-trading portion of the program after 2010, with cumulative verified emission reductions totaling nearly 700 million metric tons of carbon dioxide (CO_2) since 2003.

Ford was also one of the original companies to join the U.K. Emissions Trading Scheme, the first voluntary, government-sponsored, economy-wide, cross-industry GHG trading program. Ford Motor Company Limited (U.K.) entered the program in March 2002, committing to and achieving a 5 percent CO_2 reduction for eligible plants and facilities over five years.

Ford now participates in the mandatory EU Emissions Trading System, which commenced in January 2005 and is one of the policies being introduced across Europe to reduce emissions of CO_2 and other greenhouse gases. The second phase of this program ran from 2008 to 2012, coinciding with the first Kyoto Commitment Period. The third trading period began in January 2013 and will run through December 2020.

Despite Ford facilities' low-to-moderate CO_2 emissions (compared to other industry sectors), the EU Emissions Trading System regulations apply to seven Ford facilities in the U.K., Belgium and Spain. The trading scheme requires us to apply for emissions permits, meet rigid emissions monitoring and reporting plans, arrange for third-party verification audits and manage tax and accounting issues related to emissions transactions.

Ford is actively involved in an ongoing evaluation of the EU Emissions Trading System at both the EU and member-state levels. We have used the experience gained from participating in the market-based mechanisms described above to ensure that we operate in compliance with the scheme's regulatory framework. Ford anticipated the start of the EU Emissions Trading System and established internal business plans and objectives to maintain compliance with the new regulatory requirements.

Through our participation in these programs, we built a world-class CO_2 tracking infrastructure for our facility emissions. We will continue to leverage this system to support mandatory and voluntary reporting globally, to measure progress against our new facility CO_2 target, and to ensure compliance with the EU Emissions Trading System program and the new mandatory U.S. Environmental Protection Agency reporting requirements.

Comprehensive reporting forms the foundation for all emissions trading. We voluntarily report GHG emissions in the U.S., Canada, Mexico, Argentina, Australia, Brazil, China, and Taiwan. Mandatory reporting is required in U.S., Canada, Australia, Europe. This reporting, which has won several awards, is discussed in the Greening Our Operations section.

Related links

External Websites

→ EU Emissions Trading Scheme

Greening Our Products

As we are a customer- and product-driven company, our vehicles are the foundation of our business. Our products are also the source of our most significant environmental impacts, and are the focus of our efforts to reduce those impacts. In this section we report on the current environmental performance of our products and our efforts to "green" our products, or improve their environmental impacts.

Specifically, we address:

- Our approach to life cycle analysis including how we quantify our environmental impacts and apply lifecycle analysis in our product development process.
- Our Sustainable Technologies and Alternative Fuels plan, which lays out our plan to improve the fuel efficiency of our products and advance the use of alternative fuels including electricity and bio-fuels. We have already implemented all of the near-term and many of the mid term elements of this plan.
- Vehicle fuel efficiency and CO_2 emissions progress and performance, following our vehicles + fuel + driver = GHG emissions approach to understanding vehicle emissions during the "use phase" of a vehicle's lifecycle.
- Non-carbon-dioxide tailpipe emissions, including hydrocarbons, nitrogen oxides, carbon monoxide and particulate matter that can contribute to smog formation and other air-pollution issues.
- Sustainable materials, including efforts to increase our use of recycled and renewable materials, improve vehicle-interior air quality and eliminate substances of concern.
- Our approach to electrified vehicles, which includes hybrid electric, plug-in hybrid electric and all-electric vehicles.

Related links

This Report

→ Climate Change

Life Cycle Analysis

We use a life cycle approach to understand, assess and reduce the adverse impacts of our products. Life cycle analysis considers the materials and energy use and emissions generated over the entire life cycle of our products from cradle to grave, including raw material acquisition, material production, product manufacture, product use, product maintenance, material and component recycling and recovery, and disposal at end of life. For vehicles, this includes the environmental burdens associated with mining ores, producing materials (e.g., steel, aluminum, brass, copper, plastics, etc.), fabricating them into parts, assembling the parts into a vehicle, operating the vehicle over its entire lifetime, producing fuel for the vehicle, maintaining the vehicle and finally, dismantling the vehicle at the end of its life. We use the knowledge gained from this kind of analysis to help us minimize negative impacts up front in product design decisions and to balance environmental, social and economic aspects in our product development process.

We are incorporating life cycle assessment (LCA) in different ways across our business functions. For example, our research teams are using LCA to filter and prioritize projects, and engineers are using LCA to help select one material or design alternative over another. We are also seeing increased use of LCA throughout the industry. For example, environmental advocates are performing their own LCAs in parallel with ours. These external analyses, which often use a different set of assumptions about life cycle impacts, sometimes confirm and sometimes challenge our findings. We will continue to develop and implement a portfolio of LCA tools internally. Furthermore, we will continue to work with other LCA experts to agree on standard methodologies and assumptions to facilitate credible life cycle comparisons.

As we continue expanding our product portfolio from vehicles powered by traditional internal combustion engines running on petroleum-based gasoline or diesel to a wider range of powertrains and fuels, life cycle analysis becomes increasingly important and complex. Therefore, we are increasing our use of life cycle analysis to understand the relative impacts and benefits of alternative powertrains such as electrified vehicles and alternative fuels including electricity and compressed natural gas. We are also using these analyses to help customers understand and choose among the wide range of more sustainable vehicles available in today's marketplace.

We are working to improve the life cycle sustainability of our products and operations across our value chain. Among our product sustainability efforts, we are increasing our use of sustainable materials and eliminating undesirable materials such as heavy metals and substances that are known to be common allergens. We are also working to reduce greenhouse gases and other emissions from our facilities and vehicles by developing cleaner and more energy-efficient production processes, improving the efficiency of our packaging and transportation logistics and introducing cleaner and more fuel-efficient vehicles. Downstream in our value chain, we are working with drivers to educate them on ways to increase fuel economy and reduce vehicle emissions – for example, through driver interface technologies and our eco-driving program. Upstream, we are working with our suppliers to increase the sustainability of our products throughout the supply chain.

The remainder of this section focuses on how we are using life cycle analyses to quantify the environmental impacts of our products and how we are applying that knowledge to improve product development decisions and help customers choose more sustainable products.

Related links

This Report

- Sustainable Materials
- Vehicle Fuel Efficiency and CO_2 Progress and Performance

Quantifying Our Environmental Impacts

The first step in improving the life cycle performance of our products is to understand the environmental aspects of our products and the potential environmental impacts associated with them[1]. Much of our work to understand the environmental impacts of our products has focused on understanding their life cycle carbon- dioxide (CO_2) emissions but we are also working to understand the life cycle water impacts of our products and the different fuels they use.

Related links

This Report

Electrification: A Closer Look

Water

Assessing Life Cycle Vehicle CO_2 Emissions

Estimates of vehicles' total life cycle CO_2 emissions vary depending upon the specifics of the vehicle analyzed and the vehicle's powertrain and fuel type. For example, based on assessments of the Ford Fiesta, Focus and Mondeo, we found significant differences in life cycle CO_2 emissions among the three vehicle models and between different engine and fuel types within a vehicle model. In all cases the "vehicle use" phase produces the largest portion of life cycle CO_2 emissions (for example, 77 percent of the total for the Focus diesel, 73 percent for the Focus diesel ECOnetic version, and 83 percent for the Mondeo gasoline). Vehicles with better fuel economy do reduce the use phase's contribution to life cycle CO_2 emissions; however, the use phase remains the dominant phase for most environmental impacts. See the table below for comparisons of life cycle CO_2 emissions across these four vehicles.

Lifecycle CO_2 Emissions Comparison across Vehicle Models, Engines and Fuel Types

Vehicle Model	Engine	Fuel Type	Lifecycle CO_2 emissions
2013 Ford Focus ECOnetic	1.6 L	Diesel	23 metric tons*
2013 Ford Focus	1.0 L	Gasoline	27 metric tons
2011 Ford Fiesta	1.25 L	Gasoline	30 metric tons
2011 Ford Fiesta	1.6 L	Diesel	21 metric tons
2011 Ford Focus	1.6 L	Gasoline	32 metric tons
2011 Ford Focus	1.6 L	Diesel	27 metric tons
2011 Ford Kuga	2.0 L	Diesel	36 metric tons
2011 Ford Mondeo	2.0 L	Gasoline	42 metric tons
2011 Ford Mondeo	2.0 L	Diesel	37 metric tons

* 1 metric ton = 1,000 kg = 0.98 U.K. tons = 1.1 U.S. tons

Assessing the Life Cycle Emissions of Electrified Vehicles

Assessing vehicle life cycle energy consumption and greenhouse gas emissions is becoming a more complicated task as we add alternative fuels and powertrains to our vehicle lineup. For conventional gasoline- and diesel-powered vehicles, most of the energy is consumed, and most of the life cycle CO_2 emissions are released when the vehicles are driven, rather than when they are manufactured, maintained or recycled at end of life. As vehicle fuel efficiency improves and lower-carbon fuels are made available, the relative contribution of CO_2 emissions from the in-use phase will decrease. For plug-in hybrid electric vehicles (PHEVs), battery electric vehicles (BEVs) and hydrogen-powered fuel cell vehicles (FCVs), most of the life cycle CO_2 emissions are released during the production of the electricity or the hydrogen that provides the energy for the vehicle. A systems perspective that considers the full impacts of both the vehicle technology and fuel technology is thus required when considering the CO_2 emissions and energy use associated with alternative vehicle technologies. BEVs and FCVs are capable of achieving very low CO_2 emissions, particularly when powered by low-CO_2 electricity or low-CO_2 hydrogen. For all of our products, the emissions associated with the generation and delivery of their fuel has an impact on their life cycle emissions.

To better understand the impacts of different powertrain choices on life cycle CO_2 emissions, we compared the relative impacts and benefits of different propulsion technologies for a Focus-sized vehicle on a life cycle basis. We learned that for a battery electric vehicle (BEV) Focus, the carbon footprint of the electricity source used to charge the electric vehicle is the critical factor in determining whether or not the BEV has superior life cycle CO_2 emissions compared with a conventional Focus. In our study, we assumed the Focus BEV used electricity from sources below 400 g of life cycle CO_2/kWh – such as the electricity currently used in California, Norway and Switzerland. Based on this study, we found that the most cost-efficient, low-CO_2 vehicles for customers are the Focus variants powered by the EcoBoost® engine or advanced diesel engines. If lower carbon electricity sources are used to charge the Focus BEV, however, the electric vehicle has lower life cycle CO_2 emissions than a Focus with EcoBoost or advanced diesel engines. For hybrid electric vehicles (HEVs) the range of life cycle CO_2 emissions is similar to advanced diesel and CNG vehicles on the lower end and advanced gasoline vehicles at the upper end, depending on driving conditions. The life cycle CO_2 emissions of PHEVs, like BEVs, are significantly impacted by the carbon footprint of the electricity.

Understanding the Life Cycle Water Footprint of Our Vehicles

As part of our continuing focus on reducing water use and the development of our global water strategy, we are also using life cycle analysis to understand the water footprint of our vehicles. Our global water strategy, released in 2014, continues our focus on understanding and reducing our water-related impacts within our own facilities, and includes our supply chain. We are currently estimating fresh water withdrawal and consumption for the life cycle of a model year 2012 Ford Focus. Water withdrawal is water removed from the ground or diverted from a water source, while water consumption is water that is consumed and not available for further use. In this analysis, we are accounting for both direct and indirect water use throughout the life cycle including impacts from the vehicle itself (e.g., vehicle manufacturing and vehicle use) and impacts from the fuel used in the vehicle (e.g., production of fuel). We plan to share more details on the results of this analysis in future updates.

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1. Environmental aspects is a term used in the ISO 14001 framework to denote elements of an organization's activities, products and services that can interact with the environment. Potential environmental impacts include any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's activities, products or services. Local Ford facilities use corporate lists of environmental aspects and potential impacts to identify and amplify those aspects that apply to their operations.

Applying Life Cycle Analysis

We are applying the knowledge gained through life cycle analysis in real world decisions including in our own product development decisions and in tools that help our customers choose more sustainable products. This section provides some examples of our practical applications of life cycle analysis.

Improving Our Products with Product Sustainability Index

Our Product Sustainability Index (PSI) represents one of our most advanced applications of life cycle analysis in product development decisions. This tool, which has been used in our European product development operations since 2002, helps us to assess and find opportunities to reduce the impacts of our products over their entire life cycle – including environmental impacts such as global warming from greenhouse gas emissions, societal questions such as pedestrian protection and economic issues such as cost of ownership.

Ford's PSI tracks eight product attributes identified as key sustainability elements of a vehicle: life cycle global warming potential (mainly carbon dioxide (CO_2) emissions); life cycle air-quality potential (other air emissions); the use of sustainable materials (recycled and renewable materials); vehicle interior air quality; exterior noise impact (drive-by noise); safety, as measured by the European New Car Assessment Program (including for occupants and also pedestrians); mobility capability (seat and luggage capacity relative to vehicle size); and life cycle ownership costs (full costs for the customer over the first three years).

Since 2002 we have been applying the PSI as a sustainability management tool in the development of all of our major new European vehicles. As a result of using the PSI assessment system, all of these models have shown improvements in environmental, social and/or economic performance when compared with the previous models. The chart below shows specific performance and areas of improvement for each model. The PSI will be used on all future products developed by Ford of Europe. Detailed reports on the PSI analysis for these vehicles can be downloaded from Ford of Europe's website.

PSI Assessed Model Performance

Life Cycle Global Warming

Method
Emissions of CO_2 and other greenhouse gases from raw material extraction to material, part and vehicle production, driving period (150,000 km, incl. air conditioning) and final recycling/recovery (i.e., full vehicle lifecycle, cradle-to-cradle)

	Performance*	Better/Worse than Previous Model
2013 Ford Focus 1.6L TDCi ECOnetic	23 tonnes CO_2	Better
2013 Ford Focus 1.0L EcoBoost Petrol	27 tonnes CO_2	No previous model
2013 Ford Focus Electric	33 tonnes CO_2	No previous model
2013 Ford Focus Electric (with recommended electricity)	12 tonnes CO_2	No previous model
2011 Ford Focus, 1.6 L, Gasoline	32 metric tons CO_2 equivalent	Better
2011 Ford Focus, 1.6 L, Diesel	27 metric tons CO_2 equivalent	Better
2009 Ford Fiesta ECOnetic, Diesel	21 metric tons CO_2 equivalent	Better
2009 Ford Fiesta, Gasoline	30 metric tons CO_2	Better

	equivalent	
2008 Ford Kuga	37 metric tons CO_2 equivalent	No previous model
2007 Ford Mondeo 2.0L TDCi Diesel with DPF	37 metric tons CO_2 equivalent	Better
2006 Ford S MAX 2.0L TDCi with DPF	39 metric tons CO_2 equivalent	Similar
2006 Ford Galaxy 2.0L TDCi with DPF	40 metric tons CO_2 equivalent	Similar

*1 metric ton = 1,000 kg

Life Cycle Air Quality

Method

Summer smog-related emissions from raw material extraction to material, part and vehicle production, driving period (150,000 km, incl. air conditioning) and final recycling/recovery (i.e., full vehicle lifecycle, cradle-to-cradle)

	Performance	Better/Worse than Previous Model
2013 Ford Focus 1.6L TDCi ECOnetic	21 kg ethene	Better
2013 Ford Focus 1.0L EcoBoost Petrol	26 kg ethene	No previous model
2013 Ford Focus Electric	8 kg ethene	No previous model
2013 Ford Focus Electric (with recommended electricity)	5 kg ethene	No previous model
2011 Ford Focus, 1.6 L, Gasoline	30 kg ethene equivalent	Better
2011 Ford Focus, 1.6L Diesel	25 kg ethene equivalent	Better
2009 Ford Fiesta ECOnetic, Diesel	22 kg ethene equivalent	Better
2009 Ford Fiesta, Gasoline	32 kg ethene equivalent	Better
2008 Ford Kuga	35 kg ethene equivalent	No previous model
2007 Ford Mondeo, 2.0-L TDCi Diesel with DPF	35 kg ethene equivalent	Better
2006 Ford S MAX, 2.0L TDCi with DPF	37 kg ethene equivalent	Similar
2006 Ford Galaxy, 2.0L TDCi with DPF	37 kg ethene equivalent	Similar

Sustainable Materials

Method

Use of recycled and natural materials

	Performance	Better/Worse than Previous Model
2013 Ford Focus 1.6L TDCi ECOnetic	5.3% of non-metals	Better
2013 Ford Focus 1.0L EcoBoost Petrol	5.4% of non-metals	No previous model
2013 Ford Focus Electric	5.3% of non-metals	No previous model
2013 Ford Focus Electric (with recommended electricity)	5.3% of non-metals	No previous model
2009 Ford Fiesta ECOnetic, Diesel	8.5% of non-metals	Better
2009 Ford Fiesta, Gasoline	9% of non-metals	Better
2008 Ford Kuga	6% of non-metals	No previous model
2007 Ford Mondeo 2.0L TDCi Diesel with DPF	7.5% of non-metals	Better
2006 Ford S MAX 2.0L TDCi with DPF	18 kg of non-metals	Better

2006 Ford Galaxy 2.0L TDCi with DPF	18 kg of non-metals	Better

Substance Management

	Performance	Better/Worse than Previous Model
2013 Ford Focus 1.6L TDCi ECOnetic	Designed against rigorous standards based on certified processes	Better
2013 Ford Focus 1.0L EcoBoost Petrol	Designed against rigorous standards based on certified processes	No previous model
2013 Ford Focus Electric	Designed against rigorous standards based on certified processes	No previous model
2013 Ford Focus Electric (with recommended electricity)	Designed against rigorous standards based on certified processes	No previous model
2009 Ford Fiesta ECOnetic, Diesel	Substance management, TÜV-tested interior and pollen filter efficiency	Better
2009 Ford Fiesta, Gasoline	Substance management, TÜV-tested interior and pollen filter efficiency	Better
2008 Ford Kuga	Substance management, TÜV-tested interior and pollen filter efficiency	No previous model
2007 Ford Mondeo, 2.0L TDCi Diesel with DPF	Substance management, TÜV-tested interior and pollen filter efficiency	Better
2006 Ford S MAX, 2.0L TDCi with DPF	Substance management, TÜV-tested pollen filter efficiency and allergy-tested label	Better
2006 Ford Galaxy, 2.0L TDCi with DPF	Substance management, TÜV-tested pollen filter efficiency and allergy-tested label	Better

Drive-by-Noise

Method

Decibel level weighted to human ear dB(A)

	Performance	Better/Worse than Previous Model
2013 Ford Focus 1.6L TDCi ECOnetic	68 dB(A)	Better
2013 Ford Focus 1.0L EcoBoost Petrol	66 dB(A)	No previous model
2013 Ford Focus Electric	69.7 dB(A)	No previous model
2013 Ford Focus Electric (with recommended electricity)	69.7 dB(A)	No previous model
2011 Ford Focus, 1.6L Gasoline	66 dB(A)	Better
2011 Ford Focus, 1.6L Diesel	68 dB(A)	Better
2009 Ford Fiesta ECOnetic, Diesel	69 dB(A)	Better
2009 Ford Fiesta, Gasoline	72 dB(A)	Similar
2008 Ford Kuga	72 dB(A)	No previous model
2007 Ford Mondeo 2.0L, TDCi Diesel with DPF	69 dB(A)	Similar
2006 Ford S MAX, 2.0L TDCi with DPF	71 dB(A)	Better
2006 Ford Galaxy, 2.0L TDCi with DPF	71 dB(A)	Better

Euro NCAP (independent safety rating)

Method

Complex method, structural stability, occupant safety, and pedestrian safety; active safety elements, etc., including European New Car Assessment Program (Euro NCAP) stars

	Performance	Better/Worse than Previous Model
2013 Ford Focus 1.6L TDCi ECOnetic	5-star overall safety rating	Better
2013 Ford Focus 1.0L EcoBoost Petrol	5-star overall safety rating	No previous model
2013 Ford Focus	Not tested	No previous

Electric		model
2013 Ford Focus Electric (with recommended electricity)	Not tested	No previous model
2011 Ford Focus, Gasoline and Diesel	5-star overall safety rating, plus 4 Euro NCAP Advanced rewards for Active City Stop, Lane Keeping Aid, Forward Alert and Driver Alert	Better
2009 Ford Fiesta ECOnetic, Diesel	5-star Euro NCAP rating for adult occupant safety; electronic stability control available for all versions	Better
2009 Ford Fiesta, Gasoline	5-star Euro NCAP rating for adult occupant safety; electronic stability control available for all versions	Better
2008 Ford Kuga	Euro NCAP safety rating: 5 stars for adult occupant protection, 4 stars for child occupant protection and 3 stars for pedestrian protection	No previous model
2007 Ford Mondeo, 2.0L TDCi Diesel with DPF	Euro NCAP safety rating: 5 stars for adult occupant protection, 4 stars for child protection and 2 stars for pedestrian protection	Better
2006 Ford S MAX, 2.0L TDCi with DPF	Euro NCAP safety rating: 5 stars for adult occupant protection, 4 stars for child protection and 2 stars for pedestrian protection	Better
2006 Ford Galaxy, 2.0L TDCi with DPF	Euro NCAP safety rating: 5 stars for adult occupant protection, 4 stars for child protection and 2 stars for pedestrian protection	Better

Mobility Capability

Method

Mobility service (including seats, luggage) to vehicle size; measured as vehicle shadow in m^2 and luggage areas in liters

	Performance	Better/Worse than Previous Model
2013 Ford Focus 1.6L TDCi ECOnetic	8.76 m^2 shadow area, 363 liter luggage compartment	Better
2013 Ford Focus 1.0L EcoBoost Petrol	8.76 m^2 shadow area, 363 liter luggage compartment	No previous model
2013 Ford Focus Electric	8.76 m^2 shadow area, 237 liter luggage compartment	No previous model
2013 Ford Focus Electric (with recommended electricity)	8.76 m^2 shadow area, 237 liter luggage compartment	No previous model
2011 Ford Focus, Gasoline and Diesel	8.76 m^2 shadow area, 363 liter luggage compartment	Similar
2009 Ford Fiesta ECOnetic, Diesel	7.5 m^2 shadow area, 295 liter luggage compartment	Better
2009 Ford Fiesta, Gasoline	7.5 m^2 shadow area, 295 liter luggage compartment	Similar
2008 Ford Kuga	9.5 m^2 shadow area, 410 liter luggage, 5 seats	No previous model – among best in class
2007 Ford Mondeo, 2.0L TDCi Diesel with DPF	9 m^2 shadow area, 530 liter luggage, 5 seats	Better
2006 Ford S MAX, 2.0L TDCi with DPF	10.25 m^2 shadow area, 1,171 liter luggage, 5 seats	Better
2006 Ford Galaxy, 2.0L TDCi with DPF	10.4 m^2 shadow area, 435 liter luggage, 7 seats	Similar

*1 metric ton = 1,000 kg

Life Cycle Cost*

Method

Sum of vehicle price and three years' service (fuel cost, maintenance cost, taxation) minus residual value

	Performance	Better/Worse than Previous Model
2013 Ford Focus 1.6L TDCi ECOnetic	Approx. €16,000	Better
2013 Ford Focus 1.0L EcoBoost Petrol	Approx. €15,000	No previous model
2013 Ford Focus Electric	Approx.	No previous model

	€25,000	
2013 Ford Focus Electric (with recommended electricity)	Approx. €25,500	No previous model
2011 Ford Focus, 1.6L Gasoline	Approx. €16,400	Better
2011 Ford Focus, 1.6L Diesel	Approx. €16,700	Better
2009 Ford Fiesta ECOnetic, Diesel	Approx. €13,000	Similar
2009 Ford Fiesta, Petrol	Approx. €11,000	Better
2008 Ford Kuga	Approx. €19,100	No previous model
2007 Ford Mondeo, 2.0L TDCi Diesel with DPF	Approx. €18,300	Better
2006 Ford S MAX, 2.0L TDCi with DPF	Approx. €22,100	Better
2006 Ford Galaxy, 2.0L TDCi with DPF	Approx. €23,200	Better

*No guarantee that the costs reflect market conditions (in particular dependent on assumed differences in residual value and running cost).

Both Ford's own internal assessments and external assessments have found the PSI to be an effective life cycle assessment and design tool. An external study, conducted by experts in life cycle science and sustainability, found the PSI to be a design and analysis step that provides a full sustainability assessment and meets the requirements of ISO 14040, the international life cycle assessment standard. The PSI assessments of the 2006 S MAX and Galaxy vehicles were certified against the ISO rules for life cycle assessment. This certification process also verified the overall PSI methodology used for all subsequent PSI-developed models.

Comparing Material Choices with Life Cycle Analysis

We also use life cycle analysis to help us assess the environmental and cost impacts of different vehicle material choices. For example, we evaluated the relative benefits of using soy-based foam compared with traditional petroleum-based foams and found a net decrease of 5.5 pounds of CO_2 per pound of soy oil used over the life cycle of the vehicle. We now use soy-based foam in all of our vehicles in North America. We are now developing a life cycle analysis tool to understand the potential benefits and trade-offs of using bio-based composite materials in automotive components in collaboration with the University of Michigan's Center for Sustainable Systems. We have used this life cycle-based material selection tool to evaluate a cellulose-reinforced polypropylene composite used in grill shutter housing and found that it has overall advantages in energy and global warming impacts compared with the glass-fiber reinforced composite. For more information on soy-based foam and other renewable materials, please see Renewable Materials

Life cycle analysis also underpinned our decision to dramatically increase the amount of aluminum and high strength steel used in the 2015 F-150. Our studies show that using more aluminum, high strength steel and other lightweight materials lowers the vehicles' life cycle CO_2 emissions. Though the energy required to make these materials can be higher than the energy needed to produce the steel that is typically used, the increase in CO_2 emissions resulting from production-related energy use is more than offset by the CO_2 reduction from lowering vehicle weight and thereby improving vehicle fuel efficiency. We also found that lightweighting has the most life cycle CO_2 benefits on larger, heavier and more powerful vehicles. The use of aluminum and high-strength steel in the 2015 F-150 also makes the truck stronger, more durable and more capable than any previous F-150. For more information on the 2015 F-150, please see Case Study: The New F-150.

Helping Fleet Customers with Life Cycle Analysis Tools

In 2012, we launched a suite of tools that use life cycle analysis and other analytical strategies to help fleet customers compare the sustainability and cost benefits of the different vehicle technology and alternative fuel options available in today's marketplace. The toolkit allows fleet customers to assess the CO_2 footprint of their existing vehicle fleet and make side-by-side comparisons of emissions and fuel costs for different vehicle types, powertrain options, fuel options and personalized user criteria such as local fuel costs, regional and local electricity sources, and driving behavior. Based on this information, the tool helps a customer assess the relative emissions and cost benefits of different vehicle options. For example, for a customer deciding the best location to add electric vehicles to his or her fleet, the calculator shows that the Focus Electric emits about 70 g CO_2/km using electricity from the low-carbon California grid but more than twice as much, about 150 g CO_2/km, in the more coal-intensive Southeast U.S. The calculator enables our fleet customers to both save money and protect the environment. For more information on this suite of tools, please see our Ford Fleet Purchase Planner™ case study.

Sustainable Technologies and Alternative Fuels Plan

Overview of Our Plan

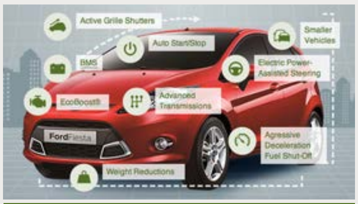
In 2007, we set out an ambitious plan of vehicle technology and alternative powertrain and fuel actions to meet our climate stabilization goals. For the past seven years, we have consistently implemented this plan, delivering significant improvements in the fuel economy of our global product portfolio and enabling the use of alternative fuels.

A Portfolio Approach

Ford is taking a portfolio approach to provide consumers with a range of different options that improve fuel economy and overall sustainability while still meeting individual driving needs. We call this strategy the “power of choice.”

Improving Fuel Economy

Though the fuel economy of modern vehicles has improved significantly over the past few decades, there are still opportunities to further improve vehicles with traditional gasoline and diesel powertrains. We are implementing a range of advanced engine and transmission technologies as well as improving aerodynamics and reducing weight.



Migration to Alternative Fuels and Powertrains

Alternative fuels and powertrains are playing a growing role in reducing carbon emissions. We are implementing a range of alternatives to conventional internal combustion vehicles including electrified vehicles – i.e., hybrids, plug-in hybrids and all-electric vehicles – as well as vehicles that run on renewable biofuels, natural gas and propane, and implementing advanced clean diesel technologies. We are also working to advance hydrogen fuel cell vehicle technologies.

Overview of Our Plan

Our sustainable technologies and alternative fuels plan, mapped out in 2007, is our route to improving the fuel economy and cutting the carbon dioxide (CO_2) emissions of our products around the world. We remain committed to the plan and have completed the near-term actions and are currently implementing the mid-term actions.

✓ indicates action completed

In Place

Fundamental technologies in place

- ✓ Significant number of vehicles with EcoBoost® engines
- ✓ Diesel use as market demands
- ✓ Electric power-assisted steering – begin global migration
- ✓ Battery Management Systems – begin global migration
- ✓ Aerodynamics improvements
- ✓ Dual-clutch and six-speed automatic transmissions replace four- and five-speeds
- ✓ Increased unibody applications
- ✓ Introduction of additional small vehicles
- ✓ Auto start-stop systems (micro-hybrids) introduced
- ✓ Add hybrid electric vehicle (HEV) applications
- ✓ Flexible-fuel vehicles
- ✓ Compressed natural gas (CNG) prepped engines available where select markets demand

Near Term

Fully implement fundamental technologies; introduce significant weight savings

- EcoBoost engines available in nearly all vehicles; engine displacement reduction aligned with vehicle weight savings
- ✓ Electric power-assisted steering – high volume
- ✓ Additional aerodynamics improvements
- ✓ Six-speed automatic transmissions – high volume
- Introduce substantial weight reductions; 250–750 lbs.
- ✓ Increased application of Auto Start-Stop
- ✓ Increased use of hybrid technologies
- ✓ Introduction of plug-in hybrid electric vehicle (PHEV) and battery electric vehicle (BEV)
- ✓ Vehicle and powertrain capability to leverage available renewable fuels
- Develop fuel cell stack technology

Mid Term

Expand weight savings, hybrids and plug-ins

- Introduce second-generation EcoBoost and advanced tech diesel
- Efficient heating, ventilation and air conditioning for HEVs, PHEVs and BEVs
- High-volume eight-plus speed automatic transmissions
- Continued weight reduction actions via advanced materials
- Increase volume of HEV and PHEV technologies
- Evolve BEV and PHEV ecosystems
- Optimize engines/vehicles for higher octane/alternative fuels
- Introduction of fuel cell electric vehicles

Long Term

Leverage hybrids and introduce alternative energy sources

- Second-generation EcoBoost and advanced tech diesels – high volume
- Continued efficiencies in electrical architecture and intelligent energy management
- Lightweight materials proliferate to global platforms
- Next-generation HEV and PHEV technologies
- Continued leverage of BEVs
- Engines capable of operating on fuels with increased renewable hydrocarbons
- Fuel cells migration timing aligned with fuels and infrastructure availability

A Portfolio Approach

In the very early years of our industry, automotive engineers experimented with a variety of methods for powering vehicles, including electricity and biofuels. The internal combustion engine using petroleum-based gasoline and diesel rose to the top fairly quickly, and has been the standard vehicle power source for the past 100 years. Reminiscent of those early years, we are now in a period of intense development and adoption of new vehicle technologies and fuels. At this time, however, there is no single winner in the race for the vehicle of the future.

That is why Ford is taking a “portfolio approach” to developing sustainable technologies and alternative fuel options. Our goal is to provide diversity in fueling options, in order to meet customers’ differing needs, while improving vehicle energy efficiency and long-term sustainability. We are thus providing customers with a range of affordable, fuel-efficient vehicles, advanced powertrains and alternative-fueled vehicle options – including fuel-efficient EcoBoost® gasoline engines, advanced diesel engines, hybrids, plug-in hybrids, all-electric vehicles and alternative-fuel vehicles. We call this approach the “power of choice,” because it allows customers to choose the vehicle that best meets their driving needs.

Giving Customers the “Power of Choice”

To deliver this “power of choice” strategy we are developing global vehicle platforms that are compatible with a wide range of fuels and powertrain technologies. This allows us to offer a portfolio of options to our customers, target options to regions where they make the most sense, and evolve our vehicles as technologies and markets develop. Global vehicle platforms that have “plug-and-play” compatibility with a wide range of technologies will also allow us to make the range of fuel and powertrain options available more affordably. For example, we have introduced an all-electric Ford Focus, a hybrid electric Ford C MAX, and the C MAX Energi plug-in hybrid – all built on our global C-platform.

We believe that traditional gasoline- and diesel-powered vehicles with internal combustion engines will continue to be a major part of the mix for quite some time. So we are working to improve the fuel efficiency of the engines and transmissions of our current vehicles, along with every vehicle subsystem.

Also, we currently produce a range of flexible-fuel vehicle models across our global markets; these vehicles can run on either regular gasoline or E85 (a blend of 85 percent ethanol and 15 percent gasoline). In South America, we also offer vehicles that can run on E100. Though biofuels are not available in every market, they are widely available in the U.S. and South America and in some parts of Europe, so it makes sense for us to provide this option to customers who can take advantage of it. In addition, biofuel availability is expected to increase globally. In Europe, the EU’s Renewable Energy Directive mandates that 10 percent of energy in the transportation sector must come from renewable fuels by 2020. In the U.S., the Renewable Fuel Standard requires annual increases in the volume of renewable fuels, reaching 36 billion gallons by 2022. Our flexible-fuel vehicles, which are provided at little or no additional cost, allow consumers to choose fuels based on availability and price. For the 2013 model year, we are offering 15 flexible-fuel models in the U.S.

We are also producing select vehicle models that can be converted to run on compressed natural gas (CNG) and liquefied petroleum gas (LPG) (also known as propane autogas). And, we are working with qualified vehicle modifiers to ensure that conversion to those fuels meets our quality, reliability and durability requirements. In 2013, we introduced a CNG/LPG conversion-ready F-150. We also continue to offer the Ford Transit Connect, the entire F-Series Super Duty® pickup truck and chassis cab lineup, our E-Series Van and Cutaway models, as well as our medium-duty trucks, with a CNG/LPG conversion-ready engine package. In Europe, we offer CNG and LPG conversions of various models in markets where dedicated infrastructure exists, such as Italy, Germany and the Netherlands.

CNG and LPG are particularly good options for fleet customers, such as taxi companies and delivery services, that use a central refueling system. In addition, CNG and LPG are widely available as vehicle fuels throughout South America and Europe. We are delivering CNG/LPG-ready engines to provide another lower-carbon option to those customers for whom this option makes sense.

As noted above, we have also been developing a range of electrification technologies. In fact, we now offer six electrified vehicles for sale in the U.S. – three hybrid electric vehicles, two plug-in electric vehicles and one battery electric vehicle. Our vehicle electrification strategy is based on providing customers with a variety of vehicle choices to meet their driving needs. To read more about this strategy, please see Electrification: A Closer Look. All-electric and plug-in hybrid vehicles may initially make the most sense for urban drivers and fleet users who have daily commutes under 40 miles. However, as battery and recharging options continue to advance, we expect these vehicles to work for a wider range of our customers.

In the longer term, hydrogen may emerge as a viable alternative fuel. Hydrogen has the potential to diversify our energy resources and lower life cycle greenhouse gas emissions, if low-carbon hydrogen production becomes feasible. To prepare for this, we are developing technology to power vehicles with hydrogen fuel cells. In addition, we are working to pair hydrogen fuel cell technology with vehicle electrification technologies to maximize the sustainability benefits of both technologies.

Helping Customers Assess the Options

It can be confusing for customers to understand and choose between the wide range of new fuel-efficiency technologies, advanced powertrains, and alternative-fuel vehicles available in today's marketplace. We have developed a suite of tools to help our fleet customers assess the relative cost and emissions benefits of different vehicle options based on the specific use factors of their fleet. For example, with our tools, we can help fleet managers make a side-by-side comparison the life cycle CO_2 emissions and fuel costs of different vehicles using the details of their own driving behavior, local fuel prices, and local electricity prices and sources. See our case study for more information on this and other fleet purchasing tools.

Support from Our Global Energy Model

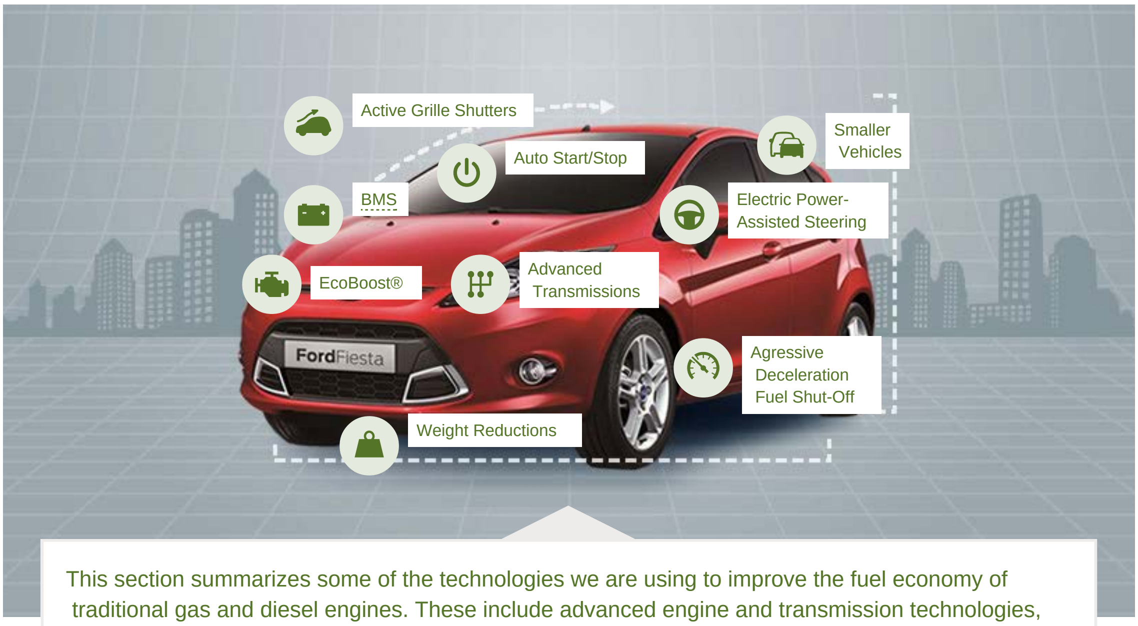
Our portfolio approach to sustainable vehicle technology and fuel options is further supported by our global energy modeling work. Ford researchers developed a global energy model to understand the combination of vehicle technologies, fuels, and energy technologies that would reduce life cycle emissions from light-duty transportation in line with our climate stabilization goal at the lowest overall cost to the economy. Our model compares different energy and fuels, vehicle technology, and technology adoption scenarios across the next 100 years. The results of this model support our belief that there is no single vehicle technology or fuel that will cost-effectively achieve the goal of climate stabilization better than our approach of developing and implementing a wide range of vehicle technology and fuel options.

This section describes our current actions and future plans to develop a wide range of energy-efficient technologies, alternative fuels and advanced powertrain technologies that will give our customers near-, mid- and longer-term options for more sustainable vehicles.

Climate Change and the Environment

- Overview
- Climate Change
- **Greening Our Products**
  - Life Cycle Analysis
  - **Sustainable Technologies and Alternative Fuels Plan**
    - Overview of Our Plan
    - A Portfolio Approach
    - **Improving Fuel Economy**
    - Migration to Alternative Fuels and Powertrains
  - Vehicle Fuel Efficiency and CO_2 Emissions Progress and Performance
  - Non-CO_2 Tailpipe Emissions
  - Sustainable Materials
  - Electrification: A Closer Look
- Greening Our Operations
- Data
- Case Study: Ford Fleet Purchase Planner
- Voice: John Fleming

Improving Fuel Economy



This section summarizes some of the technologies we are using to improve the fuel economy of traditional gas and diesel engines. These include advanced engine and transmission technologies, weight reductions, and improvements to vehicle subsystems.

For more information about each of our fuel-efficiency technologies, please click on the icons in the graphic above.

EcoBoost®

Technology Overview

The centerpiece of our near-term fuel-economy improvement efforts is the EcoBoost engine, which uses turbocharging and direct injection along with reduced displacement to deliver significant fuel-efficiency gains and CO_2 reductions, relative to larger displacement engines, without sacrificing vehicle performance.

Benefits

EcoBoost offers comparatively better value than many other advanced fuel-efficiency technologies. Due to its compatibility with most of the gas-powered vehicles we produce, we are able to offer EcoBoost's fuel-economy benefits throughout our product lineup more quickly and to a greater number of our customers. Our rapid deployment of EcoBoost in high volumes across a wide array of our vehicle nameplates is also helping us make a dramatic step forward in CO_2 emission reductions.

Deployment

Ford initially introduced the EcoBoost engine in 2009. Since then we have produced more than 2 million EcoBoost-equipped vehicles globally, responding to strong consumer demand for the technology. By the end of 2013 we offered EcoBoost engines on 15 North American nameplates. The engine is now available on 90 percent of our North American nameplates and nearly 80 percent of our European nameplates. Also, we continue to migrate EcoBoost engines to our other regions.

All told, we have introduced or announced seven EcoBoost engine displacements with multiple derivatives for specific vehicles and markets, as follows:

- 3.5L V6 EcoBoost: We introduced the first EcoBoost engine – a 3.5L V6 – in North America on the 2010 Lincoln MKS, Lincoln MKT, Ford Taurus SHO and Ford Flex. This engine provides comparable or superior performance to a normally aspirated V8 engine, but with the fuel economy of a V6. We also offer the 3.5L EcoBoost on the F-150, beginning with the 2011 model.

- 2.7L V6 EcoBoost: In 2014 we introduced a completely new twin-turbo 2.7L EcoBoost with Auto Start-Stop.
  - This engine is E85 compatible and meets California's strict low-emission vehicle (LEV III) emissions requirements.
  - This new engine will debut on the all-new 2015 Ford F-150, providing the performance of a mid-range V8 engine but with better fuel economy.
- 2.3L I-4 EcoBoost:
  - In 2014, we introduced the new 2.3L I-4 EcoBoost engine on the Ford Mustang. This Mustang will be offered globally in multiple regions for the first time ever.
  - The 2.3L will also be offered in the Lincoln MKC with front-wheel drive.
- 2.0L I-4 EcoBoost: In 2010 we introduced a 2.0L I-4 EcoBoost engine, the first in the EcoBoost lineup to go truly global.
  - In the U.S., the 2.0L I-4 EcoBoost is currently available on the Ford Edge, Explorer, Focus, Escape and Fusion. In Europe, the Ford S MAX, Mondeo and Galaxy are available with a 2.0L EcoBoost option.
  - In China, we offer the 2.0L EcoBoost on the Ford Mondeo.
  - In Australia, we offer the 2.0L EcoBoost on the Ford Mondeo and Falcon.
- 1.6L I-4 EcoBoost:
  - In Europe, the 1.6L I-4 EcoBoost engine is available on the Ford C MAX and Focus.
  - In the U.S., the engine is available on the Ford Escape, Fusion and C MAX.
- 1.5L I-4 EcoBoost:
  - Announced in early 2013, this engine will initially be produced at Ford's Craiova, Romania, Plant; other manufacturing locations will be announced in the future.
  - The new engine was introduced first in China in the all-new Ford Mondeo, and is now available on the Fusion sedan in North America and the Mondeo in Europe.
- 1.0L I-3 EcoBoost:
  - We introduced the 1.0L three-cylinder EcoBoost engine in Europe on the European Ford Focus. In 2013 we migrated this engine into the B MAX, C MAX and all-new Mondeo.
  - In the U.S., we introduced the 1.0L EcoBoost on the 2014 Ford Fiesta.
  - In India, we introduced the 1.0L EcoBoost on the Ford EcoSport. This engine will also be available in vehicles in China and other regions.

These EcoBoost engines illustrate Ford's plans to use smaller-displacement, boosted engines to deliver improved fuel economy and performance throughout our vehicle lineup. As EcoBoost is a key element of our long-term powertrain strategy, we will continue to improve its efficiency and vehicle application potential through the further development of supporting advanced technologies.

Advanced Transmissions

Technology Overview

We have adopted fuel-efficient six-speed transmissions across our product portfolio. We are now improving the performance and operating efficiency of all our transmissions by optimizing their operation with EcoBoost engines and further reducing parasitic losses such as mechanical friction, and extraneous hydraulic and fluid pumping. We are also developing more advanced transmission concepts to support additional fuel-efficiency improvements and vehicle performance benefits. For example, in 2013 we announced that we will jointly develop with General Motors an all-new generation of advanced-technology nine- and 10-speed automatic transmissions for cars, crossovers, SUVs and trucks.

Benefits

The nine- and 10-speed transmissions we are developing will improve fuel economy by up to 5 percent over six-speed gear boxes, depending on the application. In addition, they provide better acceleration, smoother shifting and a quieter driving experience.

Deployment

We have completed our migration to six-speed gearboxes in North America and Europe. We plan to start deploying the next-generation nine- and 10-speed transmissions worldwide in a few years.

Electric Power-Assisted Steering

Technology Overview

Electric power-assisted steering (EPAS) uses a small electric motor instead of conventional hydraulic systems to assist steering.

Benefits

EPAS typically will reduce fuel consumption and decrease carbon dioxide emissions by up to 3.5 percent over traditional hydraulic systems, depending on the vehicle and powertrain application. On the 1.4L Duratorq® diesel Ford Fiesta, for example, which is available in Europe, EPAS provides a 3 to 4 percent improvement in fuel efficiency compared with a hydraulic-based power steering system. By combining EPAS with aerodynamic improvements, we improved the mileage of this vehicle by approximately 8 percent compared to the previous model year. These fuel efficiency improvements – and associated reductions in CO_2 emissions – help us deliver vehicles that qualify for lower emissions-related taxation brackets in some countries. EPAS also enables other advanced technologies such as "pull drift" compensation, which detects road conditions – such as a crowned road surface or crosswinds – and adjusts the EPAS steering system to help the driver compensate for pulling and drifting. EPAS also enables Active Park Assist, which helps drivers to parallel park.

Deployment

We already offer EPAS in the Ford Explorer, F-150, Mustang, Fusion, Flex, Taurus and Escape and the Lincoln MKS, MKT and MKZ Hybrid in North America; the Ford C MAX, Focus, Focus ST and Fiesta in North America and Europe; and the Ford Ka and Kuga in Europe. EPAS is also used in all of our new electrified vehicles.

Auto Start-Stop

Technology Overview

"Start-Stop" technology shuts down the engine when the vehicle is stopped and automatically restarts it before the accelerator pedal is pressed to resume driving. Start-Stop technology includes sensors to monitor functions such as cabin temperature, power supply state and steering input, so that vehicle functioning remains exactly the same to the driver as when the engine remains on continuously. If the system senses that a vehicle function has been reduced and will negatively impact the driver's experience, the engine will restart automatically.

Benefits

This technology maintains the same vehicle functionality as that offered in a conventional vehicle, but saves the fuel typically wasted when a car is standing and running at idle. Savings vary depending on driving patterns. On average, it improves fuel efficiency by 3.5 percent, but it can improve fuel efficiency even more in city driving. The technology can also reduce tailpipe emissions to zero while the vehicle is stationary – for example, when waiting at a stoplight.

Deployment

In the U.S., we introduced the technology on the all-new 2013 Ford Fusion with 1.6L engine and automatic transmissions. In 2014, it is available in the U.S. on the Ford Fusion with 1.5L EcoBoost engine. In Europe, Auto Start-Stop is already standard on the Ford Ka and certain versions of the Mondeo, S MAX, Galaxy, Focus, C MAX and Grand C MAX. By 2016, 90 percent of our vehicle nameplates globally will be available with Auto Start-Stop.

Weight Reductions

Technology Overview

We are also working to improve fuel economy by decreasing the weight of our vehicles – in particular by increasing our use of unibody vehicle designs, lighter-weight components and lighter-weight materials.

We are using lightweight materials, such as advanced high-strength steels, aluminum, magnesium, natural fibers, and nano-based materials to reduce vehicle weight. And, some of our advanced engine and transmission technologies, such as EcoBoost® and our dual-clutch PowerShift transmissions, further reduce overall vehicle weight.

Benefits

In general, reducing vehicle weight reduces fuel use. To achieve our fuel-efficiency goals, we need to reduce the weight of our vehicles by 250 to 750 pounds, without compromising vehicle size, safety, performance or customer-desired features. Weight reductions alone may have relatively small impacts on fuel economy. By itself, a 10 percent reduction in weight results in approximately a 3 percent improvement in fuel efficiency. However, if vehicle weights can be reduced even more substantially, it becomes possible to downsize the powertrains required to run the vehicle. Weight reductions combined with powertrain rematching not only improves fuel economy, but helps maintain overall performance (compared to a heavier vehicle with a larger engine).

Many lightweight materials also have benefits beyond fuel-efficiency gains. To learn more about the benefits of natural fiber materials, please see the Sustainable Materials section.

Deployment

The all-new 2015 Ford F-150 represents our most extensive use of lightweight materials ever. Overall, this truck is up to 700 pounds lighter than the outgoing model thanks to extensive use of high-strength steels and aluminum alloys. This significant weight reduction not only results in better fuel economy, it also allows the new F-150 to tow more, haul more, and accelerate and stop more quickly. To accomplish this weight reduction, we increased the use of high-strength steel in the all-new Ford F-150 frame from 23 percent to 77 percent to create a pickup frame that is stronger, more durable and structurally more rigid than the previous generation F-150, while saving up to 60 pounds of weight. The F-150's body also uses new applications of aluminum alloys, which not only reduce weight but also improve the dent resistance and overall durability of the truck body. The specific materials used were carefully tested and analyzed based on their durability, overall performance, and life cycle environmental impact. For more information on our use of life cycle analysis in choosing materials for this vehicle, please see the Life Cycle Analysis section. For more detail on our development of this vehicle and what it means to our company, please see our F-150 case study.

Other examples of our use of lighter-weight materials in a range of vehicles and parts applications, include:

- In 2012, we announced that the all new Transit Van will replace the E-series van in the United States. This van makes extensive use of lighter-weight high-strength steel and boron steel. It has an average of 25 percent better fuel economy and haul at least 300 pounds more than today's E-Series.
- In 2012, we introduced a new, lightweight, injection-molded plastic technology called MuCell on the all-new Ford Escape. Manufacturing MuCell involves the highly controlled use of a gas such as carbon dioxide or nitrogen in the injection-molding process, which creates millions of micron-sized bubbles in uniform configurations, lowering the weight of the plastic part by more than one pound per vehicle. This is the first time MuCell has been used in an instrument panel. In addition to reducing weight, the MuCell microcellular foam saves money and production time. On the 2012 Escape, MuCell saves an estimated $3 per vehicle versus solid injection molding, and molding cycle time is reduced 15 percent. This plastic was the Grand Award winner at the 2011 Society of Plastics Engineers competition in the "Most Innovative Use of Plastics Award" category.
- The Lincoln MKT crossover has an advanced lightweight magnesium and aluminum liftgate, which is more than 20 pounds, or 40 percent, lighter than a similar part made from standard steel.
- The Ford Explorer makes extensive use of high-strength steels. Nearly half of the vehicle's structure – including the A-pillars, rocker panels and front beams – are comprised of high- strength steels, such as boron. The Explorer also has an aluminum hood.
- In the Ford Focus, more than 55 percent of the vehicle shell is made from high-strength steel and more than 26 percent of the vehicle's structure is formed from ultra-high-strength boron steels. The Focus combines these high-strength steels with innovative manufacturing methods. For example, the vehicle's B-pillar reinforcement, a key structural part, is made from ultra-high-strength boron steel that has been produced using an innovative tailor-rolling process. The process allows the thickness of the steel sheet to be varied along its length, so the component has increased strength in the areas that are subjected to the greatest loads. The tailor-rolled B-pillar has eight different gauge thicknesses, to improve side-impact crash performance while saving more than three pounds per vehicle.
- We are also expanding our use of aluminum engine parts and all-aluminum engines. The current Mustang, for example, has an aluminum engine.
- By using high-strength steels, the European Ford Fiesta weighs approximately 40 kilograms less, depending on engine choice, even though it stands on virtually the same footprint as the previous model and has 10 kilograms of new safety features and sound insulation.

Ford researchers are also investigating additional new lightweight materials. For example, we are investigating and developing:

- New types of steel that are up to three times stronger than current steels and improve manufacturing feasibility because they can be formed into parts more easily.
- Polymeric plastic strengthening foams that are strong enough to stabilize bodywork in an accident but light enough to float on water. These foams are being used to reinforce sections of the steel auto body, such as the B-pillars.
- Surface coatings that reduce engine friction and remain intact even under the most adverse conditions.
- Alternative (copper-based) wire harness technologies that will enable significant weight reductions.
- Nanotechnology to model material properties and performance at the nano-scale, which will allow us to develop better materials more quickly and with lower research and development costs.

- Nano-filler materials in metal and plastic composites, to reduce their weight while increasing their strength. For example, we are developing the ability to use nano-clays that can replace glass fibers as structural agents in reinforced plastics. Early testing shows plastic reinforced with 5 percent nano-filler instead of the typical 30 percent glass filler has strength and lightweight properties that are better than glass-reinforced plastics.

Ford is also working to understand the health and safety issues that may be posed by nano-materials. Ford has joined with other automakers under the U.S. Council for Automotive Research umbrella to sponsor research into nano-materials' potential impact on human health and the environment. This research has addressed many health- and environment-related questions so that we can focus our nano-materials research and development in areas that will be most beneficial.

Battery Management Systems

Technology Overview and Benefits

Electrical systems are another area in which we are making progress. By reducing vehicle electrical loads and increasing the efficiency of a vehicle's electrical power generation system, we can improve fuel efficiency. Our Battery Management Systems (BMSs), for example, control the power supply system (in particular the alternator) to maximize the overall efficiency of the electrical system and reduce its negative impacts on fuel economy. This is accomplished by maximizing electricity generation during the most fuel-efficient situations, such as vehicle deceleration. In less fuel-efficient situations, the alternator's electricity generation is minimized to conserve fuel.

Deployment

BMSs have already been launched globally on a majority of our vehicle platforms. We will continue to implement BMSs on remaining vehicles and will continue to optimize its functionality to further improve benefits. We have also introduced more efficient alternators, which improve fuel economy.

Aggressive Deceleration Fuel Shut-Off

Technology Overview

Aggressive Deceleration Fuel Shut-Off (ADFSO) allows fuel supply to the engine to be shut off during vehicle deceleration and then automatically restarted when needed for acceleration or when the vehicle's speed approaches zero. This advancement builds on the Deceleration Fuel Shut-Off technology available in our existing vehicles by extending the fuel shutoff to lower speeds and more types of common driving conditions, without compromising driving performance or emissions.

Benefits

This improved fuel shutoff technology will increase fuel economy by an average of 1 percent. An additional benefit is increased deceleration rates, which should extend brake life and improve speed control on undulating roads.

Deployment

Starting in 2008, ADFSO was implemented on the Ford Flex, F-150, Expedition and Escape and the Lincoln MKS and Navigator. We are continuing to implement it as we bring out new vehicles. The ADFSO technology will be a standard feature in all of our North American vehicles by 2015, and we will continue to expand implementation globally.

Active Grille Shutters

Technology Overview and Benefits

Active Grille Shutter technology is one of our key aerodynamics improvements. It reduces aerodynamic drag by up to 6 percent, thereby increasing fuel economy and reducing carbon dioxide (CO_2) emissions. When fully closed, the reduction in drag means that the Active Grille Shutter can reduce CO_2 emissions by 2 percent.

Deployment

We implemented Active Grille Shutter technology first on our European vehicles. In the U.S., we have implemented it on the 2012 Ford Focus and Edge, the 2013 Ford Escape and the all-new 2013 Ford Fusion.

Smaller Vehicles

Technology Overview and Benefits

Smaller vehicles provide consumers with another way to get better fuel economy. Simply by being smaller and lighter, smaller vehicles can significantly reduce fuel use and related emissions.

Deployment

We are launching more small cars to provide more fuel-efficient options. For example:

- We introduced the all-new Ford Fiesta, our global subcompact vehicle commonly referred to as "B-car," Ford Fiesta globally.
- We are introducing a wide range of new vehicles in the U.S. and other markets based on our global "C-platform," or compact sedan. In the next few years, we are introducing 10 new vehicles based on this C-platform. For example, in North America, our C-car platform underpins the gasoline-fueled Ford Focus, the battery-electric Focus Electric, the C MAX Hybrid and C MAX Energi, a plug-in hybrid.
- We are continuing to introduce new variations of the Transit Connect small commercial van in North America. This vehicle fills an unmet need in the U.S. market by offering the large cargo space that small business owners need in a fuel-efficient, maneuverable, durable and flexible vehicle package.
- In 2012 we revealed the all-new Ford EcoSport compact SUV, which will ultimately be available in nearly 100 markets globally, including India and Brazil. This vehicle is part of our global commitment to deliver fuel-efficient vehicles that customers truly want and value.

We have loaded these smaller vehicles with features and options commonly found on larger or luxury vehicles to make them attractive, thus encouraging customers to choose more fuel-efficient cars and trucks.

All of these smaller vehicles illustrate Ford's actions to provide consumers with a wider range of fuel-efficient options, as well as our efforts to leverage the best of our global products to offer new choices to customers in all of our regions worldwide.

Climate Change and the Environment

- Overview
- Climate Change
- **Greening Our Products**
  - Life Cycle Analysis
  - **Sustainable Technologies and Alternative Fuels Plan**
    - Overview of Our Plan
    - A Portfolio Approach
    - Improving Fuel Economy
    - **Migration to Alternative Fuels and Powertrains**
      - Advanced Clean Diesel
      - Hybrid Electric Vehicles (HEVs)
      - Battery Electric Vehicles (BEVs)
      - Plug-in Hybrid Electric Vehicles (PHEVs)
      - Renewable Biofueled Vehicles
      - CNG/LPG Vehicles
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  - Vehicle Fuel Efficiency and CO2 Emissions Progress and Performance
  - Non-CO2 Tailpipe Emissions
  - Sustainable Materials
  - Electrification: A Closer Look
- Greening Our Operations
- Data
- Case Study: Ford Fleet Purchase Planner
- Voice: John Fleming

Migration to Alternative Fuels and Powertrains

Our migration to alternative fuels and powertrains includes introducing electrified vehicles – including hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) – as well as advanced Clean Diesel Technologies and vehicles that run on renewable biofuels. We are also working to advance hydrogen fuel cell vehicle (FCV) technologies.

For more information on our plans regarding each of these alternative fuels and powertrain technologies, please click on the Ford vehicles below.

Advanced Clean Diesel

Hybrid Electric Vehicles (HEVs)

Battery Electric Vehicles (BEVs)

Plug-in Hybrid Electric Vehicles (PHEV)

Renewable Biofueled Vehicles

CNG/LPG Vehicles

Hydrogen Fuel Cell Vehicles (FCVs)

Advanced Clean Diesel

Ford's New Full-Size Transit Van and F-650/750

Modern diesels are 30 to 40 percent more fuel efficient than gasoline vehicles. Ford offers a range of advanced diesels in Europe under the ECOnetic label. In the U.S., Ford will introduce a new 3.2L Power Stroke® turbo diesel engine in our full-size Transit van. That engine will join the newly upgraded, second generation 6.7L V8 Power Stroke turbo diesel offered in the F-Series Super Duty® and F-650/F-750 medium-duty commercial trucks, offering customers powerful and fuel-efficient choices.

Technology Overview and Benefits

Diesel engine technology is not in itself new. However, advanced diesel technologies offer significant advantages over traditional gasoline engines and older diesel engines. They consume 30 to 40 percent less fuel than gasoline engines, and on a well-to-wheels basis they emit 15 to 30 percent less carbon dioxide (CO_2).[1] In addition, direct-injection diesel engines provide exceptional power and torque, resulting in better driving performance and towing capabilities. Advanced diesel technology also dramatically reduces non-CO_2 tailpipe emissions such as NOx and particulate matter.

Our advanced diesel engines use a range of technologies in the engine and after-treatment systems to reduce emissions. For example, our 1.6L Duratorq® TDCi engine, used on European vehicles, includes more efficient eight-hole fuel-injector nozzles, a more powerful engine-control unit and a water-cooled charge air cooler. In addition, parasitic losses have been cut through use of low-friction piston ring coatings, a variable-flow oil pump and a more-efficient vacuum pump. After-treatment system improvements include a coated diesel particulate (soot) filter coupled with a lean NOx trap to enable Euro 5 emissions compliance.

Our diesel engines offered in the U.S also use a range of advanced after-treatment technologies to reduce emissions, including:

- a diesel oxidation catalyst that converts and oxidizes hydrocarbons into water and carbon dioxide;
- selective catalytic reduction that uses an ammonia and water solution to convert the NOx in the exhaust stream into water and inert nitrogen; and
- a diesel particulate filter that traps any remaining soot and periodically burns it away when sensors detect that the trap is full.
- The 3.2L Power Stroke diesel in the Transit van combines the diesel oxidation catalyst and diesel particulate filter in a single, package-efficient component.

Deployment

In Europe, where diesel-powered vehicles account for more than 50 percent of new vehicle sales and make up approximately 30 percent of the total vehicle fleet on the road, Ford continues to improve its strong lineup of fuel-efficient and clean diesel vehicles. For example, we continue to introduce ECOnetic versions of Ford models that deliver improved fuel economy and emissions. The ECOnetic lineup currently includes versions of the Ford Fiesta, Focus, Mondeo and Transit. Several of the ECOnetic models use diesel engines, which meet the stringent Euro 5 emissions standards and emit less than 100 g/km of CO_2. For example, the new Focus ECOnetic has fuel economy of 3.4L/100 km and emits just 89 g/km of CO_2.

In North America, where diesel engines are primarily used in the medium-duty truck market, Ford offers two advanced diesel engines. In 2015, we will introduce a diesel version of the full-size Transit van, powered by a new 3.2L Power Stroke turbo diesel engine. Like the larger 6.7L Power Stroke V8 diesel, which Ford introduced on F-Series Super Duty trucks in 2011, the 3.2L turbo diesel engine's fuel system has been carefully tailored and calibrated for combustion efficiency. It enables the newest Power Stroke engine to achieve exceptional fuel-economy ratings without affecting power levels.

These new diesel engines meet the U.S. Environmental Protection Agency's and California Air Resources Board's strict medium duty chassis and heavy-duty truck emission regulations.

Our advanced diesel engines are also compatible with biodiesel, a renewable fuel made from soybean oil and other fats. The 2011 Super Duty is Ford's first vehicle in North America that is B20 compatible, meaning it can run on fuel composed of 20 percent biodiesel and 80 percent ultra-low-sulfur diesel. The diesel Transit van is B20 compatible. In Europe, our vehicles are compatible with B7, and we are working with European fuel standards organizations to establish fuel-quality standards for biodiesel blends greater than B5. The use of biodiesel helps to reduce dependence on foreign oil and reduces life cycle CO_2 emissions. For more information on biofuels, please see the Renewable Biofueled Vehicles section.

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1. Figures based on J.L. Sullivan, R.E. Baker, B.A. Boyer, R.H. Hammerle, T.E. Kenney, L. Muniz, and T.J. Wallington, 2004, "CO_2 Emission Benefit of Diesel (versus Gasoline) Powered Vehicles," Environmental Science and Technology, 38: 3217-3223

Hybrid Electric Vehicles (HEVs)

Ford C MAX Hybrid

Hybrid electric vehicles are powered by a traditional internal combustion engine and battery power to deliver improved fuel economy.

Technology Overview and Benefits

HEVs are powered by both an internal combustion engine and an electric motor with a battery system. The key benefit of HEVs is reduced fuel consumption: When they are powered by the electric motor and battery system, they do not burn gasoline. In most instances at low speeds and for short distances, Ford hybrids run exclusively on electricity. At higher speeds, and when more power is needed, the gasoline engine kicks in.

All of our hybrid vehicles use Ford's powersplit architecture, meaning they can run exclusively on battery power, exclusively on gas power or on a combination of both to deliver the best overall fuel efficiency. Ford hybrids also feature a Regenerative Braking System. Unlike a traditional gasoline engine in which the energy generated by braking is lost, this innovative technology enables Ford hybrids to capture braking energy normally lost and use it to help recharge the battery.

In the past our HEVs used nickel-metal-hydride batteries. The HEVs we now produce use more advanced lithium ion batteries. For more detail on our battery technologies, please see Battery Technologies.

Our new HEVs feature additional technology improvements, including:

- Electric motors capable of operating at higher electric speeds,
- Optimized gear ratios, allowing for improvements in fuel economy,
- More precise controls to deliver higher levels of refinement as the powertrain transitions between engine and electric drive, and
- Reduced weight to help increase fuel economy.

Our new hybrids also have a suite of driver information systems to help drivers maximize fuel efficiency. For more information on these technologies, please see Helping Drivers Improve Fuel Efficiency with Information Technology.

Deployment

We are currently increasing our hybrid volume and preparing for hybrid capability across our highest-volume global product platforms.

In 2013-14, in the U.S. we offer the C MAX Hybrid and Fusion Hybrid, both of which were launched in 2012, and the Lincoln MKZ hybrid. The C MAX hybrid is one of three electrified vehicle options on our C-platform; the others are the Focus Electric battery electric vehicle (BEV) and the C MAX Energi plug-in hybrid electric vehicle (PHEV). The C MAX Hybrid uses Ford's powersplit hybrid architecture, with improved fuel efficiency and a lighter, smaller lithium ion battery system. The Fusion is the first sedan to offer gasoline, hybrid and plug-in hybrid powertrains, underscoring Ford’s commitment to giving customers the “power of choice” in fuel-efficient technologies. In 2014, we plan to introduce a hybrid version of Ford Mondeo in Europe.

Battery Electric Vehicles (BEVs)

Ford Focus Electric

Electric vehicles use no gasoline; they are powered by a high-voltage electric motor and battery pack. Ford currently offers one BEV in the U.S., the Focus Electric, which has a U.S. Environmental Protection Agency (EPA) combined fuel-economy rating of 105 miles per gallon equivalent (MPGe), a driving range of 76 miles on a charge and requires no more than four hours to charge when using a 220-volt outlet.

Technology Overview and Benefits

Battery electric vehicles do not have an internal combustion engine and do not use any on-board gasoline. Instead, they use a high-voltage electric motor, which gets its power from a high-voltage battery pack charged by plugging into a standard 110-volt or 220-volt outlet in the U.S., or a 230-volt outlet in Europe. The primary benefit of BEVs is that they completely eliminate carbon dioxide (CO_2) and other emissions directly from the vehicle. However, they are not necessarily zero-emission over their total lifecycle, depending on the source of electricity used to charge their batteries. Because electricity is often cheaper than gasoline, BEVs may be less costly to operate than gasoline vehicles.

Ford's electric vehicles use lithium-ion batteries, which provide better performance, require less space and weigh less than the nickel-metal-hydride batteries used in previous-generation hybrid electric vehicles. The Focus Electric's advanced lithium-ion battery system was engineered by Ford in cooperation with the supplier LG Chem. It uses an advanced, active-liquid cooling and heating system to precondition and regulate the temperature, which helps to maximize battery life and fuel-free driving range.

A full recharge of the Focus Electric takes just four hours at home with the 240-volt charge station. The Focus Electric also features a Regenerative Braking System, which can help maximize vehicle driving range by capturing braking energy and using it to recharge the battery. And, the vehicle uses a wide range of advanced information-technology features, including an enhanced version of MyFord Touch® – our new driver interface technology – and tools for remote vehicle communications and charging. For more information on these technologies, please see Living the Electric Lifestyle.

Deployment

We are implementing an expanded, comprehensive electric vehicle strategy aligned with growing public interest in advanced technologies that reduce the use of gasoline and diesel. To read more about our overall approach, please see Electrification: A Closer Look.

The Focus Electric, our all-electric passenger sedan is based on the all-new Focus. This car has a driving range of 76 miles on a single charge of its lithium-ion high-voltage battery and achieves an EPA-rated combined fuel efficiency of 105 MPGe. We introduced the Focus Electric in the U.S. in 2012 and in Europe in 2013.

Plug-in Hybrid Electric Vehicles (PHEVs)

Ford C MAX Energi

Plug-in hybrid electric vehicles are powered by an internal combustion engine and a high-voltage electric battery that can be charged from an electric outlet. The engine and the battery work together to provide the benefits of grid-connected power and hybrid powertrain efficiency. Ford offers two PHEVs in the U.S., the C MAX Energi and the Fusion Energi.

Technology Overview

PHEVs are similar to HEVs in that they are equipped with both an electric battery and a gas-powered engine. Unlike HEVs, however, PHEVs are equipped with a high-capacity battery that can be charged from a private household or public electric outlet. While regular HEVs maintain a roughly constant battery charge, PHEVs discharge the battery while driving to provide additional fuel savings. PHEVs have the potential to reduce tailpipe emissions to near zero when running on battery power. When the battery is depleted, the vehicle can continue to operate on the gas-powered engine, providing significant benefits over battery electric vehicles in terms of driving range before refueling. A PHEV's overall life cycle emissions depend on the electrical power source and the usage characteristics of the vehicle. PHEVs can be significantly less expensive for consumers to operate than gasoline-powered vehicles, particularly for consumers who take relatively short trips most of the time. During such trips, PHEVs allow drivers to travel on grid-based electricity stored in batteries instead of more costly gasoline.

The high-voltage battery is charged through regenerative braking and discharged during acceleration events to improve the overall fuel economy of the vehicle – similar to the operation of today's conventional hybrids.

Benefits

Overall, plug-in hybrid vehicles offer several benefits, including:

- Reduced dependency on petroleum and increased energy independence,
- Reduced environmental impact through reductions in greenhouse gas emissions as well as smog-forming tailpipe emissions,
- Increased use of electricity from renewable energy sources (e.g., wind and solar) for vehicle recharging, and
- Potential consumer savings on energy and fuel costs.

PHEV vehicles provide the extra benefit of being able to charge the batteries at home or other parking location. This means that PHEVs might better suit those customers who do the majority of their driving in city and other urban environments, where electric battery power is the preferred powertrain alternative.

Deployment

Ford currently offers two PHEVs in the U.S.: the Ford C MAX Energi and the Fusion

Energi. We plan to introduce the C MAX Energi in Europe in 2014.

Like Ford’s HEVs, the C MAX Energi and Fusion Energi offer a range of information-technology tools to help drivers improve fuel efficiency. For more information on these technologies, please see Living the Electric Lifestyle.

The long-term success of PHEVs in the real world depends on cooperation between automakers, utilities, the government and drivers. Ford is engaged in multiple collaborative projects to help smooth the transition to electrified vehicles. For more information on this, please see Improving the Electric Vehicle Ecosystem in our Electrification section.

Renewable Biofueled Vehicles

Ford Galaxy

Biofuels offer a relatively affordable way to reduce carbon dioxide (CO_2) emissions. To date, we have introduced more than 6.3 million flexible-fuel vehicles globally. Ford is a market leader and pioneer in ethanol-powered, flexible-fuel vehicles and will continue to provide a range of products that are E85-capable, aligned with infrastructure growth and consumer demand.

Technology Overview

Biofuels are alternative forms of gasoline and diesel made from renewable sources, usually plant materials. Ethanol, the most common biofuel alternative used with gasoline, is made from the fermentation of sugars, most commonly corn sugars (in the U.S. and Europe) or sugar cane (in Brazil). Biodiesel, a biofuel alternative to petroleum diesel, is made from the transesterification of vegetable oils, including soy, canola, palm and rapeseed, or from animal fat. Most biodiesel in the U.S. is made from soybeans. Biofuels are primarily used in blends with petroleum-based fuels. Gasoline is mixed with ethanol and diesel is mixed with biodiesel). In the U.S., most retail market gasoline already contains up to 10 percent ethanol (referred to as E10). E85, a mix of 85 percent ethanol and 15 percent gasoline, is also available. For biodiesel, in the U.S. the most commonly blend is 5 percent or 20 percent biodiesel mixed with petroleum-based diesel (B5 and B20 respectively), while in Europe a 7 percent biodiesel blend (B7) is most commonly used.

Modern gasoline vehicles can run on gasoline blends up to 10 percent ethanol (E10) in the U.S. without any modifications. Vehicles require minimal modifications to run on gasoline blends above E10, such as hardening seals in the engine, which can be corroded by solvents in biofuels. Today vehicles in Brazil meeting different requirements operate on E25. Modern compression ignition engines, which are made to run on petroleum-based diesel, also require some modifications to run on biodiesel. For more information about biofuels, biofuel infrastructures, and challenges, please see the Fuels section. For more information on our approach to renewable fuel policy, please see the Renewable Fuels Policy section.

Benefits

Biofuels are an important component of our sustainability strategy for three reasons. First, biofuels can help to address economic, social and environmental sustainability, which includes helping us meet our CO_2 emission-reduction targets. Second, the use of biofuels requires relatively modest and affordable modifications to existing vehicle and fueling technology, which makes them a viable near-term option. Third, biofuels offer synergies with our other strategies. For example, the high octane rating of ethanol is a potential enabler for the introduction of higher compression-ratio engines and higher engine-boost technologies that improve the efficiency and torque of our future downsized engines.

Deployment

Ford has a long history of developing vehicles that run on renewable biofuels. Our founder, Henry Ford, was a strong proponent of biofuels, and we produced our first flexible-fuel vehicle (FFV) approximately 100 years ago: The Ford Model T was capable of running on gasoline or ethanol.

Ford has taken a leadership position on biofuels. Since 1997, we have offered FFVs capable of running on gasoline or E85 ethanol (or E100 hydrous ethanol in Brazil). In the U.S., we met our commitment to double our FFV production from 2006 to 2010. To date, we have introduced more than 6.3 million FFVs globally. Ford FFV models are available in many European markets as well.

In Europe all of our new diesel vehicles can run on B7, a blend containing 7 percent biodiesel. We have worked with fuel standards organizations to allow the use of biodiesel blends of greater than B7 in our future products. In order for biodiesel to be a success, it is critical that the fuel be blended to meet stringent standards for quality and consistency. In the U.S., since 2012 our F-Series Super Duty® trucks with a 6.7L diesel engine are compatible with B20, and we expect the new Transit van with a 3.2L turbo diesel to be B20-compatible as well. In addition, the gasoline version of these vehicles will be flexible-fuel compatible with gasoline, E85 or any ethanol-gasoline blend between E0 and E85.

CNG/LPG Vehicles

Ford F-150 Pickup

Vehicles that run on compressed natural gas (CNG) and liquefied petroleum gas (LPG – also called propane autogas) typically have lower emissions and lower fuel costs than gasoline and diesel vehicles. Ford offers engine packages specially prepared for conversion to run on CNG and LPG on many of our vehicles targeted to the commercial fleet market.

Technology Overview

Ford offers engine packages specially prepared for conversion to run on compressed natural gas (CNG) and liquefied petroleum gas (LPG – also called propane autogas), on many of our vehicles targeted to the commercial fleet market. CNG and LPG can help commercial vehicle fleets reduce their environmental footprint because they provide similar performance with significantly lower emissions. They can also help fleets reduce fuel costs, as they typically cost less on a gallon-equivalent basis than gasoline or diesel. Commercial fleets can also take advantage of centralized refueling and/or defined routes, which help address fueling infrastructure issues. Our gaseous-fuel-prepped engines include hardened components such as valves and valve seats that can withstand the higher operating temperatures and lower lubricity of gaseous fuels.

Our vehicles with gaseous-prepped engines can be converted to either dedicated alternative fuel systems, which can only run on either CNG or LPG, or to bi-fuel systems, which can run on the alternative fuel or on regular gasoline. Bi-fuel vehicles generally have longer range because they have the combined range of both on-board fuel types and can continue to operate seamlessly on gasoline when the alternative fuel is not available.

Benefits

CNG and LPG vehicles have both environmental and economic advantages. Vehicles using these fuels have lower carbon dioxide (CO_2) emissions and lower total greenhouse gas (GHG) emissions than gasoline or diesel vehicles. When running on CNG, vehicles typically emit about 25 percent less CO_2 and about 10 percent fewer total GHGs on a well-to-wheels basis, according to Argonne National Laboratory's GREET model. LPG-fueled F-series trucks typically emit 17 to 24 percent fewer total life cycle GHG emissions, according to a study commissioned by the Propane Education and Research Council. CNG and LPG also reduce non-CO_2 tailpipe emissions such as NOx, SOx, particulate matter and carbon monoxide.

CNG and LPG also have significantly lower fuel costs. In the U.S., CNG costs range from approximately $1.50 to $2.80 per gallon[1] on a gasoline-gallon equivalent basis, resulting in a 40 to 75 percent reduction in fuel cost compared to using diesel or gasoline. Businesses using CNG-fueled trucks often see payback on the conversion cost in as little as 24 to 36 months of use. In the U.S., LPG costs approximately $2.00 per gallon, on a gasoline-gallon equivalent basis, resulting in an up to 50 percent fuel savings per gallon compared to gasoline and diesel.

While CNG provides better GHG and fuel costs reductions, LPG can have other benefits. For example, LPG refueling systems typically cost significantly less to install. LPG fuel tanks are also smaller than CNG, resulting in less loss of cargo and/or passenger capacity.

Deployment

Interest in CNG and LPG vehicles is growing globally. In the U.S., for example, sales of Ford's commercial vehicles with CNG/LPG prepped engine packages increased by more than 350 percent from 2009 to early 2013. Today, CNG/LPG prep packages are purchased 3 to 5 percent of Ford vehicles that offer this option. In the U.S., we provide gaseous prepped engine packages as a factory installed option on select commercial vehicles. We work with qualified vehicle modifiers (QVM) to convert vehicles with gaseous prepped engines to CNG and LPG fuel systems. Ford has established a rigorous qualification program for QVMs that provides guidance, modification recommendations, and engine operating specifications required to ensure customer satisfaction and reliability in line with Ford Motor Company standards. We perform on-site assessments at each QVM location to ensure conformance to a high standard of manufacturing, assembly, workmanship and customer service. We currently work with five QVM suppliers for CNG conversions (Altech-Eco, IMPCO, Landi Renzo, Venchurs and Westport) and one QVM for LPG conversions (ROUSH CleanTech).

Ford's approach to CNG and LPG vehicle conversions using QVMs offers a range of benefits. For example, the competition among QVMs has resulted in improved quality and reduced prices for conversion systems, as well as spurring innovation and technology improvements. This approach has made it possible for Ford to offer a much wider range of commercial vehicles with CNG and LPG than other full-line manufacturers.

In the U.S., Ford vehicles currently available with CNG and LPG gaseous fuel prepped engine packages include:

- F-150 Pickup, 3.7L
- Transit Connect, 2.5L
- Transit variants including full-size vans, wagons, cutaways, and chassis cabs with 3.7L
- E-Series Cargo Vans, 5.4L/6.8L
- E-Series Wagons, 5.4L/6.8L
- E-Series Cutaway & Stripped Chassis, 5.4L/6.8L
- F-Series Super Duty® Pickup & F-350 Chassis Cab, 6.2L
- F-Series Super Duty Chassis Cabs, F-450/550/650, 6.8L
- F-53 & F-59 Stripped Chassis, 6.8L
- Lincoln MKT Town Car limousine livery packages with 3.7L

For the U.S. market, Ford is also currently developing CNG/LPG-prepped engine packages for:

- The all new-F-650 Medium Truck

In Australia, Ford offers LPG versions of the Falcon Ute commercial vehicle using Ford's EcoLPi engine technology. In Europe, we offer CNG and LPG conversions of various models in markets where dedicated infrastructure exists, such as Italy, Germany and the Netherlands. In Germany, for example, we offer CNG bi-fuel versions of the Ford C MAX and Focus. In India, we offer a bi-fuel CNG version of the Ford Ikon Flair.

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1. Based on prices from January 2014 available at http://www.cngnow.com/average-cng-prices/pages/default.aspx

Hydrogen Fuel Cell Vehicles (FCVs)

Ford Focus

Hydrogen fuel cell vehicles are electric vehicles powered by hydrogen fuel cells. The fuel cells are essentially batteries fueled by hydrogen. They emit just water vapor and heat, without other tailpipe pollutants.

Technology Overview and Benefits

Hydrogen fuel cell vehicles are similar to battery electric vehicles (BEVs) in that they use a high-voltage electric motor to propel the vehicle. Unlike BEVs, however, FCVs are equipped with a hydrogen fuel tank and a fuel cell system that generates electric power to drive the electric motor. So FCVs use onboard hydrogen stored in the fuel tank and refueled in minutes, while BEVs are powered by electric energy stored in the high-voltage battery. As a result, FCVs provide the environmental benefits of a BEV but they have a longer driving range and significantly shorter refueling time.

In an FCV, an automotive fuel cell propulsion system runs the vehicle by converting hydrogen and oxygen into electrical current through an electro-chemical reaction in the fuel cell stack. It emits just water vapor and heat, without other tailpipe pollutants. Therefore, FCVs are considered to be zero- emission vehicles. FCVs can also be hybridized with a high-voltage battery, to improve vehicle performance and better optimize the cost and robustness of the fuel cell propulsion system. In fact, all of our efforts to improve high-voltage electronics, electric motors, regenerative braking and battery technology on BEVs, HEVs and PHEVs can be applicable to FCVs, if and when these vehicles become commercially viable.

We believe that hydrogen-powered fuel cell vehicles may be an important long-term solution for improving energy security and diversifying our energy sources, as well as for reducing greenhouse gas emissions, if hydrogen fuel emerges as a viable low-carbon energy carrier. Therefore, Ford has committed to significant hydrogen fuel cell research and development.

Deployment

Technology Demonstration

Ford has been working on fuel cell vehicle development and technology demonstration for more than a decade. From 2005 to 2009, we participated in a technology demonstration program partially funded by the U.S. Department of Energy (DOE), as well as in other government-supported demonstration programs in Canada and Europe. A total of 30 Ford Focus FCVs were in operation in these programs. These vehicles were tested to demonstrate technical feasibility, performance durability and reliability. For example, they were subjected to driving tests at sub-zero temperatures and high altitudes to prove vehicle performance under a range of customer-encountered driving environments. By 2009, these vehicles had accumulated more than a million driving miles without significant technical problems, thereby demonstrating the reliability of fuel cell powertrain systems in real-world driving conditions. The data collected from this fleet have been critical to the further development of Ford's fuel cell technology. Based on the knowledge gained in this first generation of fuel cell technology, we have completed development and laboratory validation of additional generations of fuel cell technologies. These later-generation technologies improve the robustness and "freeze start" capability of the fuel cell propulsion system.

Challenges of Commercialization

Even with the advances we have made in hydrogen technology over the past 10 years, we still have challenges to overcome before hydrogen FCVs can compete in the market with current vehicle technology. The cost and durability of the fuel cell system are the most significant challenges. For example, extensive DOE analysis has not yet revealed an automotive fuel cell technology that meets the DOE's targets for real-world commercialization, or that maintains proper performance throughout the targeted lifetime while staying within the targeted cost. There are also still significant challenges related to the cost and availability of hydrogen fuel and onboard hydrogen storage technology. To overcome these challenges and make fuel cell vehicle technology commercially viable, we believe further scientific breakthroughs and continued engineering refinements are required.

Continuing Research and Development

Given these significant challenges to commercialization, Ford had reprioritized its internal resources to concentrate on core fuel cell research that will help increase the commercialization potential of FCVs, including materials development and basic scientific research to solve cost and durability challenges.

In January 2013, however, we announced a partnership with Daimler AG and Nissan Motor Co., Ltd., to accelerate the commercialization of fuel cell vehicle technology by jointly developing a common fuel cell system that will reduce technology costs by maximizing design commonality, leveraging volume and deriving efficiencies through economies of scale. This collaboration could to lead to the launch of the world's first affordable, mass-market fuel cell electric vehicles as early as 2017.

We are continuing our core fuel cell research as well. Our materials research is focused on the membrane electrode assembly (MEA) and bipolar plates, which make up key cost and/or durability elements of the fuel cell stack. For example, we are working to develop a new fuel cell catalyst that will significantly reduce the use of precious metals, such as platinum, and we are exploring alternatives to expensive components, such as developing low-cost corrosion-resistant bipolar plates. Simultaneously, we are working to increase the power density of the individual fuel cell stack. This could potentially reduce the use of the expensive materials and components in the stack. MEA research is also crucial to our ability to optimize fuel cell stack operating conditions and reduce system complexity. We are working on the fuel cell stack research and development with our alliance partners: Daimler AG and the Automotive Fuel Cell Cooperation (AFCC), a Vancouver-based company owned by Ford and Daimler AG. We are also working to optimize the overall propulsion-system architecture to take advantage of advances in fuel cell materials and lessons learned from our demonstration FCV fleet. By developing advanced computational modeling that will help us understand the mechanisms underlying ideal fuel cell functioning and anticipate failure modes under real-world usage, we are able to propose operating strategies and system architectures that minimize fuel cell propulsion system costs. These modeling tools support our fuel cell materials and system research.

On-board hydrogen storage is another critical challenge to the commercial viability of hydrogen FCVs. Current demonstration vehicles use compressed gaseous hydrogen storage. However, the high-pressure tanks required for this storage use expensive materials for reinforcement such as carbon fiber. In addition, the current tanks are large and difficult to package in a vehicle without unacceptable losses in passenger or cargo space. Therefore, we are pursuing research on materials-based on-board hydrogen-storage technology, including complex hydride and novel hydrogen sorbent technologies, which may ultimately achieve higher energy density and lower cost.

Hydrogen Refueling Infrastructure

Producing and distributing hydrogen fuel is another important hurdle on the road to implementing hydrogen-powered FCVs and hydrogen-powered internal combustion engines (H_2ICEs). The GHG-reduction benefits of hydrogen fuel depend on what procedures and feedstocks are used to produce the hydrogen. Currently, the most state-of-the-art procedure is a distributed natural gas steam-reforming process. However, when FCVs are run on hydrogen reformed from natural gas using this process, they do not provide significant environmental benefits on a well-to-wheels basis (due to GHG emissions from the natural gas reformation process). It would be necessary to employ carbon-sequestration technologies in hydrogen production from fossil fuels or increase the use of renewable energy sources to enable the hydrogen for hydrogen-fueled FCVs to provide significant environmental benefits.

Even if the challenges of producing hydrogen can be overcome, there is still no widespread hydrogen fueling system. Therefore, new infrastructure must be invested in, designed and executed throughout the country to make hydrogen-powered vehicles commercially attractive to Ford customers.

Working alone, Ford will not be able to overcome all of the challenges hydrogen vehicles face. That is why Ford is collaborating with a wide range of partners.

Vehicle Fuel Efficiency and CO_2 Emissions Progress and Performance

How is Ford doing in its quest to improve vehicle fuel efficiency and greenhouse gas (GHG) emissions? This section reviews our progress in reducing "use-phase" vehicle emissions – those that come from the vehicles while they are being driven, rather than during their manufacture or disposal. Life cycle analyses have found that 80 to 90 percent of vehicle-related GHGs are emitted during the use phase. Please see the Life Cycle Analysis section for more information on this topic. Emissions from our operations, logistics (i.e., the transportation of parts for our vehicles and of finished vehicles to dealerships), and from our supply chain are also important elements of our greenhouse gas emission impacts and reduction strategy. These topics are covered in the Greening Our Operations section (regarding our facilities) and the Supply Chain section (regarding logistics and suppliers).

Emissions during a vehicle's use phase are obviously dependent on the vehicle's fuel economy, which in turn depends on many characteristics of the vehicle itself (such as its weight, powertrain and aerodynamics). The bulk of this section focuses on our progress in improving vehicle fuel efficiency. This progress is largely the result of implementing the technologies described in our Sustainable Technologies and Alternative Fuels Plan.

Use-phase vehicle emissions are also dependent on the "well-to-wheels" greenhouse gas profile of the fuels used in the vehicles. Therefore, we also report on progress in developing lower carbon fuels, including electrification, biofuels, and gaseous fuels including compressed natural gas (CNG) and liquefied petroleum gas (LPG, or propane autogas).

Use-phase emissions also depend on consumer vehicle choices and driving behavior. If consumers choose more fuel-efficient vehicles, the emissions from their driving will be lower, other things being equal. In addition, use-phase emissions are influenced by how customers drive and maintain their vehicles. The amount and nature of consumer driving is an important factor in determining total motor vehicle GHG emissions, but it is often ignored. So, this section also discusses our efforts to help drivers improve the fuel efficiency of their driving behavior.

Our shorthand for these three factors influencing use-phase vehicle emissions is:

Vehicle + Fuel + Driver = GHG Emissions

Vehicle

Improving Vehicle Fuel Efficiency

To meet our climate change goals, we are focused in the near term on implementing the most cost-effective fuel-efficiency technologies across a large volume of our vehicles, as well as on introducing new products that offer improved fuel efficiency without compromising style or performance. We are concentrating on affordable and near-term sustainable technology solutions that can be used not for hundreds or thousands of cars, but for millions of cars, because that is how Ford can truly make a difference.

For each of our new or significantly refreshed vehicles, we will continue to offer a popular version powertrain with leading fuel economy. Global platforms, such as those on which our Ford Fiesta and Focus are built, allow us to roll out our advanced technologies at a lower cost, achieving the large volumes that provide a real benefit.

We are offering our customers the "power of choice" when it comes to fuel-efficient vehicles and fuel-saving technologies – i.e., the ability to choose what best suits their needs from a wide range of advanced technologies implemented across our product lineup. To do this, we have introduced a wide variety of new engine and transmission technologies – as well as electrical system improvements, weight reductions and aerodynamic improvements – that deliver significant fuel-economy benefits for millions of drivers in the near term. We also offer electrified products, natural gas- and propane-ready engines, and vehicles that can operate on higher blends of biofuels. EcoBoost® engines, which use gasoline turbocharged direct-injection technology, are an important part of our efforts to improve vehicle fuel efficiency. EcoBoost engines significantly improve fuel economy and reduce CO_2 emissions, and provide superior driving performance compared to larger-displacement engines. Because EcoBoost is affordable and can be applied to existing gasoline engines, we can implement it across our vehicle fleet, bringing fuel-efficiency benefits to a wide range of our customers. We produced over 2 million EcoBoost engines globally by the end of 2013, surpassing our previously announced goal of producing 1.5 million in that timeframe. We now offer EcoBoost engines on 90 percent of our North American and European nameplates, and 80 percent of our nameplates globally. In addition to EcoBoost engines we now offer a wide range of fuel-efficient technologies on our conventionally fueled vehicles, including advanced transmissions and Auto Start-Stop.

We offer six electrified vehicles (EVs) in the U.S: the all-electric Focus Electric, the Fusion Energi and C MAX Energi plug-in hybrid electric vehicles (PHEVs), and three hybrid electric vehicles (HEVs). We launched the Focus Electric in Europe in 2013 and plan to launch the C MAX Energi plug-in hybrid and a hybrid electric version of the Ford Mondeo in Europe in 2014. We plan to launch additional electrified vehicles in other global markets in coming years. Consumer interest in EVs grew in 2013. In 2013, the total number of EVs sold in the U.S. was 596,948, which accounted for a 3.8 percent of the total vehicles sold, up from 492,319 sold in 2012, which was 3.3 percent of vehicles sold in 2012.[1] In 2013 Ford sold over 87,000 EVs including battery electric vehicles (BEVs), HEVs, and PHEVs – an all-time record for Ford. EV sales accounted for 3.5 percent of company sales, up from 1.6 percent share in 2012. Our overall share of the EV market also grew substantially. In the fourth quarter of 2013, our retail EV market share was 14.3 percent, up from 6.5 percent in 2013. While Ford's share of the electrified vehicle market is growing, electrified vehicles still only represent a small fraction of U.S. sales. Electrified vehicles still have a long way to go to get significant penetration in a market that is still dominated by gasoline-powered vehicles.

In 2014, we will introduce the 3.2L Power Stroke® diesel engine in the U.S. in the fuel-efficient Transit full-size van. This engine, which will be manufactured in South Africa, adds to our lineup of advanced, clean diesel technologies used in vehicles marketed around the globe.

In Europe we also offer advanced common rail diesel engines across our European model range, as well as an ECOnetic Technology range of low-CO_2 vehicles.

We have committed that for each of our new or significantly refreshed vehicles, we will offer a powertrain with leading fuel economy. For more information on our overall approach to fuel-efficient and alternative powertrain technologies, please see our Sustainable Technologies and Alternative Fuels Plan.

The following are some examples of our fuel-efficient vehicles and progress in improving fuel efficiency by region.

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North America

In North America, we continued to introduce new vehicles that use the technologies identified in our Sustainable Technologies and Alternative Fuels Plan, and that offer outstanding fuel economy and reduced CO_2 emissions.

In 2013 in the U.S., we improved the average fuel economy of our car fleet by 2 percent, and of our truck fleet by 3 percent compared to 2012. However, our combined U.S. corporate average fuel economy decreased by 1.7 percent in 2013 due to increased customer demand for trucks over cars. Fleet CO_2 emissions improved by 11 percent compared to 2008.

We now have the most fuel-efficient vehicle lineup in our company's history.

We also continued to expand the use of our EcoBoost engines, which significantly improve the fuel economy of gasoline engines. As of the end of 2013, 90 percent of our North American and European nameplates offer EcoBoost engines.

We have made significant progress in improving the fuel economy of, and hence reducing the CO_2 emissions from, our vehicles in North America. Figure 1 illustrates the improvement in fuel economy of key Ford vehicle models from 2004 to 2014.

Figure 1: Nameplate fuel economy improvement summary

Model		2004–2014 MY % FE Improvement[2]
	Focus	24.5[3]
	Escape	26.9
	Explorer	29.0[4]
	F-150	19.2[5]

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Europe

Ford offers one of the broadest low-CO_2 vehicle portfolios in Europe. Our efforts to improve fuel efficiency are paying off. Preliminary data shows that we have reduced the average CO_2 emissions of our European car fleet by around 18 percent between the 2007 and 2013 calendar years.[6]

We are using a variety of technologies to accomplish these gains. We offer three ECOnetic vehicles, ultra-low-CO_2 versions of selected Ford diesel vehicles that leverage several advanced, fuel-saving technologies. The ECOnetic name was chosen because it links ecologically sensitive technology to our "energy in motion" design philosophy, which combines driving quality and emotional styling.

In addition, we offer three EcoBoost gasoline engines in Europe, the 2.0L, 1.6L, and the 1.0L EcoBoost engines. These engines are available on the Ford Fiesta, B MAX, EcoSport, C MAX, Grand C MAX, Focus, Modeo, S MAX, and Galaxy. They are available in combination with other fuel-saving technologies such as Auto Start-Stop, Smart Regenerative Charging, Active Grille Shutter, and EcoMode. Ford is the only non-premium manufacturer currently offering Active Grille Shutter.

In 2013 and 2014 we are also extending our global electric vehicle plan to Europe. We launched the Focus Electric, an all-electric vehicle, in June 2013. We will launch the C MAX Energi, plug-in hybrid and a hybrid version of the Mondeo in late 2014. We also offer compressed natural gas (CNG) and liquefied petroleum gas (LPG, or propane autogas) versions of the Ford Fiesta, Focus, B MAX, C MAX, and Mondeo. And, we offer a flex-fuel version of the Ford Focus that can run on E85 (85 percent ethanol). All of our diesel vehicles can run on up a fuel blend of up to seven percent bio-diesel (B7).

Some examples of vehicles we offer in Europe with best-in-class, or extremely low-CO_2 include:

- The Fiesta delivers best-in-class fuel economy with a 1.0L EcoBoost engine that achieves 4.3L/100 km and 99 g/km CO_2.
- In total, we now offer seven versions of the new Fiesta with CO_2 emissions below 100 g/km.
- The Fiesta ECOnetic, Ford's most fuel-efficient and lowest-CO_2-emission passenger car ever, offers fuel economy of 3.3L/100[7] km (86 mpg U.K.[8]/71 mpg U.S.) and CO_2 emissions of 85 g/km. The new model showcases technology innovations such as Auto Start-Stop, Smart Regenerative Charging, EcoMode and shift indicator light. It also benefits from a bespoke engine calibration and optimized gear ratios. A lower suspension and wheel deflectors, as well as low-rolling-resistance tires, are used to further reduce driving resistances.
- The Focus ECOnetic delivers fuel economy of 3.4L/100 km[9] (83.1 mpg U.K.[10]/69 mpg U.S.) and CO_2 emissions of 88 g/km, making it the most fuel-efficient non-hybrid family car currently available in Europe.
- The Mondeo ECOnetic has a specially calibrated 115PS (85 kW) version of the 1.6L Duratorq TDCi engine equipped with a diesel particulate filter. Due to a combination of changes compared to the standard Mondeo, the Mondeo ECOnetic is delivering a combined fuel consumption of 4.3L/100 km[11] (65.6 mpg U.K.[12]), which translates into average CO_2 emissions of 114 g/km.
- The Focus 1.0L EcoBoost model delivers best-in-class fuel economy and the lowest CO_2 emissions compared to its rivals. The 1.0L EcoBoost 100PS version delivers 4.8L/100 km[13] (58.9 mpg U.K.[14]/49 mpg U.S.) and CO_2 emissions of 109 g/km. The 125PS model returns 5.0L/100 km[15] (56.5 mpg U.K.[16]/47 mpg U.S.) with CO_2 emissions of 114g/km.
- An updated version of the Focus with an 1.0L EcoBoost 100 PS, on offer since January 2014, provides fuel economy of 4.3L/100 km (65.6 mpg U.K.[17]) and 99 g/km CO_2. This is the first non-hybrid gasoline powered family car in Europe to break the 100 g/km CO_2 barrier.

In total, Ford offers 48 models and variants in Europe with CO_2 emissions below 130 g/km, of which 13 models or variants have CO_2 emissions below 100 g/km.

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Asia Pacific Africa

In the Asia Pacific region, we are launching more vehicles equipped with the EcoBoost engine in response to growing consumer demand for more fuel efficient vehicles. We will offer EcoBoost engines in 20 vehicles in Asia Pacific by mid-decade, a five-fold increase from 2012. In 2013, EcoBoost was available in 10 vehicles in the region. The 1L I-3 EcoBoost was introduced in the region for the first time on the Ford Fiesta, available in Australia, China, New Zealand, Taiwan, and ASEAN, and the EcoSport, available in Australia, China, India, and New Zealand. Also in 2013, the 1.5L I-4 EcoBoost was available the new Mondeo in China. The new Mondeo in China is the first vehicle at Ford to include the newly introduced 1.5L EcoBoost engine. We also offer the 1.6L and 2.0L I-4 EcoBoost variants in the Edge, Kuga, Mondeo, Falcon, Focus ST, and Fiesta ST. In March 2014, Ford's joint venture, Changan Ford Automobile Co., Ltd. (CAF), began producing 1L EcoBoost engines at a new engine plant in Chongqing to power the Ford Fiesta and EcoSport vehicles built for China.

The fuel-efficient EcoBoost engines are being well received by our customers in the Asia Pacific region. In 2013, sales of EcoBoost equipped vehicles in the region rose by 250 percent compared to 2012. Seventy-seven percent of the Ford Mondeos and 90 percent of the Ford Edges sold in China are equipped with EcoBoost.

In China, Ford will upgrade its entire powertrain portfolio with 20 advanced engines and transmissions to support its aggressive plan to introduce 15 new vehicles to China by mid-decade. These advanced, fuel-efficient technologies – including turbocharging, direct injection, twin independent variable camshaft timing (Ti-VCT) and six-speed transmissions – will deliver more than a 20 percent improvement in fuel economy to Ford's passenger vehicle fleet in China by 2015, which represents a key part of Ford's near-term sustainability goals in China.

In India, we are also continuing to introduce vehicles with excellent fuel economy. In 2013, we introduced the all-new Ford EcoSport with a 1.0L EcoBoost, the first vehicle in India to have this technology. We also continue to offer the Ford Fiesta – powered by TDCi diesel powertrain developed for India – that delivers class-leading fuel economy and reduced CO_2 emissions. This builds on fuel economy leadership established with the Ford Figo, launched in March 2010, which has two engine options: a best-in-class, fuel-efficient 1.4L TDCi diesel and a very competitive 1.2L gasoline engine. In Australia, we introduced the 1.0 L EcoBoost on the Fiesta and all-new EcoSport, We also offer an EcoBoost versions of the Ford Mondeo, and Ford Falcon, Fiesta ST, Focus ST, and Kuga. Also in Australia, we offer our EcoLPi liquid-injection liquefied petroleum gas (LPG) system for the Falcon, providing customers with the most advanced LPG technology on the market. The Falcon EcoLPi fuel system improves fuel economy by 12 to 15 percent, while also improving power by approximately 27 percent over the prior LPG Falcon model.

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South America

In South America, we are improving fuel economy by introducing some of the efficient engine and transmission technologies currently used in North America, and by offering technologies compatible with the widespread use of biofuels in Brazil. We offer our EcoBoost engine on the Ford Mondeo in Argentina and the Ford Fusion in Brazil.

We are continuing to implement the new, more-efficient "Sigma" engine, which improves efficiency compared to current engines through reduced internal friction and improved electronic throttle controls. We have also improved the gearing ratios, aerodynamics and rolling resistance of our South American models, further increasing fuel economy. In Brazil, our Ford EcoSport, a B-segment SUV, is a fuel economy leader in its segment. In 2013 in Brazil, we launched the new Ford Fiesta, which received an "A" rating for fuel efficiency in the new Brazilian fuel-efficiency labeling system. Ford also received a "Seal of Excellence" award for the Ford Fusion Hybrid and 2014 model year Fiesta 1.6L TiVC in Brazil; these awards are given to vehicles in the top 20 percent for fuel economy, regardless of vehicle segment or type.

Over the past few years, we have successfully implemented a large number of fuel-efficiency technologies in our B- and C-sized vehicle segments, which make up approximately 80 percent of the Brazilian market. These include twin independent variable cam timing engines and direct-injection engines, Battery Management Systems, smart alternator systems, and dual-clutch automatic transmissions.

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1. Industry EV sales and share is estimated due to nondisclosure of data by some competitors.
2. Unadjusted combined.
3. Wagon excluded, BEV excluded.
4. Explorer Sport, Sport Trac and ethanol-fueled FFVs excluded.
5. Ethanol-fueled FFVs, natural gas and supercharged vehicles and SVT Raptor excluded.
6. The final 2013 calendar-year fleet-wide CO_2 emissions data for our European fleet will be available in November 2014. For all years, these data do not include Volvo.
7. The stated fuel consumption and CO_2 emissions are measured according to the technical requirements and specifications of the European Regulation (EC) 715/2007 as last amended.
8. The stated fuel consumption and CO_2 emissions are measured according to the technical requirements and specifications of the European Regulation (EC) 715/2007 as last amended. The European standard test drive cycle, NEDC, is used for type approval of fuel economy and CO_2 data. They differ from fuel economy calculations developed in the U.S. or other regions of the world. The fuel economy figures in mpg are based on the U.K. imperial gallon, which is 1.2

times the U.S. gallon.

9. The stated fuel consumption and CO_2 emissions are measured according to the technical requirements and specifications of the European Regulation (EC) 715/2007 as last amended.
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Fuel

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- Electrification
- Biofuels
- Compressed Natural Gas (CNG) and Liquefied Petroleum Gas (LPG or propane autogas)

Improving fuel economy alone will not reduce life cycle greenhouse gas (GHG) emissions to the levels required for carbon dioxide (CO_2) stabilization. We also need fuels with lower fossil carbon content[1], including biofuels, electricity, and gaseous fuels such as compressed natural gas (CNG), liquefied petroleum gas (LPG), and hydrogen. Ford cannot increase alternative fuel use simply by offering vehicles that can use these fuels. Widespread use of these fuels will also require significant efforts by fuel and energy providers, including continued development of the fuels themselves and considerable updating or expansion of refueling infrastructure. Government action will also be required to facilitate the adoption of common standards for fuel quality and refueling infrastructure, as well as measures such as tax incentives to encourage manufacturers to produce the fuels and consumers to use them.

In this section, we briefly discuss fuel alternatives Ford is currently implementing commercially: electrification, biofuels, and two gaseous fuels, compressed natural gas (CNG) and liquefied petroleum gas (LNG, or propane autogas). For more information on how Ford is developing and rolling out vehicles and powertrains that use these fuels, please see Sustainable Technologies and Alternative Fuels Plan.

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Electrification

Electrification addresses both energy security and climate change concerns, because electricity can be made from a wide variety of fuels, including domestic sources and renewable energy.

Ford foresees a future that includes a variety of electrified and traditional vehicles, something we call “power of choice.” We are electrifying existing, traditional vehicle lines rather than creating unique electrified vehicle models. That way, our customers can choose from a variety of vehicle powertrains, including efficient gasoline engines, hybrid electric vehicles, plug-in hybrids and full-battery electric vehicles. Our comprehensive electrification strategy touches all aspects of the electrification ownership experience, seeking to make it engaging, empowering and easy to live with.

For more information on Ford’s approach to electrified vehicles, as well as issues associated with using electricity as a vehicle fuel, please see Electrification: A Closer Look. For more information on the hybrid electric, plug-in hybrid and battery electric vehicles we have launched or plan to launch, please see the Sustainable Technologies and Alternative Fuels Plan.

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Biofuels

Biofuels are a key piece of our blueprint for sustainability to reduce CO_2. While current corn-based ethanol production in the U.S. is estimated to provide a modest (approximately 20 percent) reduction in vehicle GHG emissions on a well-to-wheels basis, next-generation biofuels such as lignocellulosic bioethanol could offer up to a 90 percent GHG reduction benefit.[2] Consistent with consumer demand, Ford will continue to provide a range of products designed to run on a wide range of ethanol blends. Flexible fuel vehicles (FFVs) provide fuel choice to consumers when the fuel is available and are necessary to transition to advanced alternative fuels.

We believe that the use of biofuels may increase from a current level of approximately 2 to 3 percent globally to 10 to 30 percent of global liquid road-transportation fuel over the next few decades. We are conducting research and development to ensure that our vehicles will be compatible with and able to incorporate the full benefits of biofuels. Our current work focuses on the two biofuels that are available at a commercial scale: ethanol and biodiesel. Biofuel use has been expanding globally. Bioethanol (frequently called just ethanol) is made from corn, beets or sugar cane and substitutes for gasoline. Biodiesel is derived from plant oils and substitutes for diesel fuel. In the U.S. in 2007, federal legislation expanded the Renewable Fuel Standard (RFS), mandating a significant increase in the use of biofuels by 2022.

The following describes issues and challenges associated with expanding the use of biofuels in vehicles.

Current Generation Biofuels

The U.S. and Brazil are the world's largest producers of ethanol, which is made from the fermentation of sugars. In the U.S. the sugar is typically derived via the hydrolysis of corn starch, while in Brazil the sugar is obtained directly from sugar cane. Ethanol is primarily used in blends with gasoline. Hydrous ethanol, which is approximately 95 percent ethanol and 5 percent water, is also used in Brazil. Blends are identified using the volumetric content of ethanol, which is specified numerically after the letter "E" for ethanol. For example, E10 is 10 percent by volume ethanol and 90 percent petroleum gasoline. Most automotive fuel supplied in the U.S. is E10. The U.S. Environmental Protection Agency (EPA) has recently issued a waiver permitting E15 to be sold in the U.S. for use in 2001 or newer model year vehicles. Our position regarding E15 is discussed in the Renewable Fuels Policy section.

An important benefit of ethanol is its higher octane rating, which can improve the efficiency and torque of today's high-efficiency internal combustion gas engines. We developed a new fundamental molecular approach to calculating the octane increase provided by ethanol blended into gasoline, which is more accurate than previous approaches.[3,4] The octane rating of a fuel is a critical fuel property that describes its resistance to "knock," which results from early or uncontrolled fuel ignition. To avoid "knocking," the compression ratios designed into engines are limited by the lowest expected octane rating of available fuels. However, engines operate at higher thermal efficiency when they can be operated at higher compression ratios using appropriate higher-octane fuel. The increased availability of ethanol in the future provides an opportunity for fuel providers to deliver fuels with higher octane ratings and automakers to provide higher compression ratios – and therefore more efficient engines.[5] For example, our studies suggest that increasing the percentage of ethanol in gasoline from the current 10 percent (E10) found in most commercially available gasoline, to 20 percent (E20) while also improving engine compression ratios to take advantage of the associated increase in fuel octane, would reduce vehicle CO_2 emissions by nearly 5 percent.[6]

High-octane ethanol blends offer a win-win-win opportunity in which the increased availability of ethanol could enable increased engine efficiency, resulting in fuel savings for our customers, improved energy security and reduced CO_2 emissions. However, ethanol blends above E10 also may damage engines that are not designed to operate on higher concentrations of ethanol; this poses a particular concern for older vehicles. Appropriate planning and coordination between stakeholders is needed to manage transition issues such as these. Our research into ethanol fuels and octane rating implications will help us take the best advantage of higher-octane ethanol-fuel blends when they are made available in the future.

Biodiesel is a biofuel alternative to petroleum diesel that is made from the transesterification of vegetable oils, including soy, canola, palm and rapeseed, or from animal fat. Biodiesel is distinct from "renewable diesel," which is made by hydrotreating vegetable oils or animal fats. In the U.S., most biodiesel is currently made from soybean oil. Biodiesel is typically used in blends with petroleum diesel, where the volumetric content of biodiesel is specified numerically after the letter "B" representing biodiesel.

Future Biofuels

The biofuels currently available at a commercial scale (e.g., ethanol and biodiesel) have advantages relative to their petroleum-derived counterparts. They can be made from locally available raw materials, providing support for rural communities and reducing the need for foreign-supplied oil, while increasing national energy security. They also reduce life cycle (or well-to-wheels) CO_2 emissions compared to conventional petroleum-based fuels. However, important issues remain regarding the energy density of some biofuels, the best way to use these fuels to reduce GHG emissions, their ability to meet fuel needs without impacting food supplies and their potential impact on land-use decisions. (These issues are discussed in more detail below in the Biofuel Challenges section.)

Meanwhile, Ford is working to support and promote the next generation of biofuels, including cellulosic biofuels. These are primarily fuels made from plant cellulose – stalks, leaves and woody matter – instead of from sugars, starches or oil seeds. Cellulosic biofuels will have many advantages. They should minimize possible market competition between food and fuel. They would allow for the more complete use of crops such as corn and soybeans by using additional parts of these crops, including stems and leaves, for fuel production. In addition, cellulosic biofuels can be made from "energy crops," such as switchgrass and wood, that require less fertilizer and less energy-intensive farming methods. This would further reduce the total CO_2 footprint of the resulting biofuels. There has been significant progress in technologies and processes to transform biomass feedstocks into ethanol in recent years and a few small-scale plants are now in operation in the U.S. and elsewhere. Technological barriers to large-scale production of cellulosic ethanol have been largely overcome. The main barrier now is the regulatory uncertainty associated with recent downward revisions of cellulosic biofuel mandates and the associated poor business case for cellulosic ethanol production in an uncertain market. Capital availability also remains a significant challenge to commercialization. Given these challenges, it is our assessment that next-generation biofuels will not be available at scale in the marketplace for at least 10 years. Looking further into the future, if additional technical breakthroughs in production efficiencies are made, and if the investment climate is sufficiently favorable to encourage the large capital outlays required to build the necessary biorefineries, next-generation biofuels could play a significant role in addressing climate change and energy security.

The United States Renewable Fuel Standard and the Future of Biofuels

The Energy Independence and Security Act of 2007 expanded the Renewable Fuel Standard (RFS) by requiring a significant increase in the use of biofuels – to a total of 36 billion gallons per year by 2022. This law also requires that, beginning in 2010, a certain portion of biofuels must be "advanced" and/or cellulosic-based fuels. Ethanol blended into gasoline is expected to supply the majority of this biofuel mandate and could displace a substantial fraction of U.S. gasoline demand by 2022.[7] The use of biodiesel in the U.S. is also likely to increase in the coming years. However, it will not likely increase to the same levels as ethanol, because the RFS mandates lower volumes of biomass-based diesel, there is less availability of cost-effective feedstock material, and because a relatively small percentage of light-duty passenger vehicles in the U.S. use diesel fuel.

Full deployment of E10 for gasoline-powered vehicles would achieve approximately one third of the RFS-mandated biofuel use by 2022. Therefore, meeting the full RFS biofuel requirement will require much greater use of E85 in FFVs and/or the development of vehicles that can use "mid-level blends" of ethanol and gasoline (i.e., between E10 and E85). The expanded use of E85 in FFVs would require a corresponding increase in the E85 fueling infrastructure in the next 10 to 20 years. An approach using mid-level ethanol blends would require that all new vehicles be designed for higher ethanol capability, and the existing fueling infrastructure would need to be updated for compatibility with fuel containing higher concentrations of ethanol. While the introduction of and expanded use of E15 might help achieve the RFS goals if carried out properly, the problems associated with the approach taken by the EPA to date (as discussed above) outweigh the benefits. For any of these approaches to be successful, the new ethanol-blend fuels will have to provide enough value to the consumer to attract them to buy these fuels. Regardless of the specific strategy used, coordinated efforts will be required between automakers, fuel suppliers, consumers and the government to meet the RFS mandate while ensuring the compatibility of vehicles and ethanol-blended fuel. Without alignment between vehicles, fuels and infrastructure, a mismatch will occur, and it will be difficult to meet the RFS mandate successfully.

Biofuel Infrastructure

More widespread use of biofuels would increase their benefits for reducing GHG emissions and improving energy security. This requires greater availability of both biofuels and vehicles capable of using biofuels. In the U.S., the E85 refueling infrastructure remains inadequate. Out of more than 160,000 refueling stations in the U.S., approximately 3,300 (or slightly more than 2 percent) offer E85. This trails the availability of E85 vehicles in the marketplace. FFVs make up approximately seven percent of the current U.S. light-duty vehicle and FFVs now account for nearly 20 percent of all new light-duty vehicles being produced. The FFV fleet is substantial and growing. To reap the energy security and climate change opportunities of the FFV fleet more infrastructure, particularly more access to affordably priced E85, is necessary.

Biofuel Challenges

Much of the interest in biofuels results from their potential to lessen the environmental impacts of transportation fuels while contributing to energy independence. Biofuels are typically made from domestic and renewable resources, they provide an economic boost to rural communities, and they help to reduce greenhouse gas emissions because the plants from which they are made absorb atmospheric CO_2 while they are growing. But are biofuels the best solution to our growing fuel-related environmental, economic and political problems? The issues are complex. We believe biofuels are an important part of the equation for addressing climate change and energy security. We recognize, however, that major advances need to be made in production processes, source materials and fuel types for biofuels to achieve their full potential.

Challenges relating to today's biofuels include the following:

- **Energy Density**: The energy density of ethanol is approximately two-thirds that of gasoline.[8] This means there is approximately one-third less available energy in a gallon of ethanol than in a gallon of gasoline. As a result, drivers using fuels containing higher amounts of ethanol will have to refuel more frequently. Ethanol does have improved qualities, such as higher octane, that can be leveraged to offset some of the lower energy content relative to gasoline. In 2012, Ford researchers published an assessment that quantified the potential benefits of high-octane ethanol gasoline blends in the U.S.[9] Biodiesel has approximately the same energy density as conventional petroleum-based diesel.
- **Lifecycle Greenhouse Gas Emissions**: The CO_2 that is released when biofuels are burned is from carbon that was captured from the atmosphere by the plants used to produce biofuel feedstocks. However, current farming and production processes utilize fossil fuels in the production of ethanol and biodiesel, so the production of these biofuels results in a release of some fossil-fuel-based GHG emissions on a complete lifecycle basis. In addition, emissions of nitrous oxide (N_2O), another GHG resulting from biofuel feedstock production, need to be carefully considered for all types of biofuel feedstocks and farming techniques on a full life cycle basis, including the appropriate allocation of emissions to co-products (such as animal feed) derived from biofuel production. Government and academic studies suggest that using E85 with ethanol from corn results in approximately 20 to 30 percent fewer life cycle GHG emissions than gasoline, on an energy-equivalent basis. GHG emissions related to petroleum can vary greatly depending on the source. Producing crude oil from tar sands, for example, results in a greater release of GHGs than producing crude oil from conventional sources. The use of renewable energy sources in the production of ethanol and biodiesel production can reduce their lifecycle GHG emissions further. We believe that developing cellulosic or biomass-based biofuels with next-generation processes will significantly decrease the GHG emissions associated with biofuels, by up to 90 percent.[10]
- **Competition with the Food Supply**: Another concern about current corn- and soybean-based biofuels is that they compete in the marketplace with food supplies and are often cited as one of the factors that increase food prices. In 1990, the production of ethanol in the U.S. consumed approximately 3 percent of the corn harvest, but in 2012 that figure was 41 percent. Ethanol production removes only the starch from the corn kernel – the remaining portion (about one-third of the weight of the corn kernel) is a highly valued feed product (called distillers grains) and a good source of protein and energy for livestock and poultry. When taking into account the livestock feed yield of the distiller's grains, about 30 percent of the U.S. corn harvest was used for ethanol production. This mitigates the competition between ethanol production and food production. In addition, the growth of the energy crop market has encouraged improvements in farming productivity (e.g., bushels per acre) that may not have occurred otherwise, further reducing the impact of biofuels on corn availability. The increase in corn used for ethanol production in the U.S. over the past 10 to 15 years has been essentially matched by the increased harvest over the same period. The increased harvest has been driven mainly by improved yield per acre and, to a lesser extent, by increased acreage. If next-generation biofuels can efficiently utilize biomass such as plant stalks, woodchips or grasses and be grown on marginal land with little irrigation, then competition with food crops should be minimized.
- **Land-Use Conversion for Biofuel Production**: Recent studies have looked at the overall CO_2 and N_2O impacts of "direct" land-use changes associated with biofuels – i.e., converting natural ecosystems to farmland for the production of crops to make biofuels. Additional studies have considered an "indirect" land-use change scenario in which the use of farmland for biofuels in one region indirectly leads to the conversion of natural ecosystems to farmland in another region due to crop market feedbacks (either replacing the grain in the marketplace or due to increased prices). Recent studies indicate that the magnitude of land-use changes in the early studies were overestimated. Significant uncertainty remains and this is an area of active research.

At Ford, we are following the debates about biofuels closely. As we proceed, we need to consider how biofuels are derived and carefully review issues such as the potential net greenhouse gas benefits; political, economic, social and environmental concerns related to biofuel and petroleum use; and the management of land, food and water resources. We agree with the general consensus among scholars and industry experts that the current generation of biofuels has modest environmental benefits and is a first step toward cleaner transportation and energy independence. We are actively investigating the potential of next-generation biofuels that have greater environmental, energy security and economic benefits. We believe that improvements in the efficiency of farming technologies and biomass production processes, and the development of advanced biofuels, will significantly increase the benefits and long-term sustainability of biofuels. Even with these improvements, solving our climate change and energy security problems will require a multifaceted set of solutions, including new fuels, improvements in vehicle efficiency, and changes in consumer driving patterns and practices.

For more information on our implementation of biofueled vehicles, please see Renewable Biofueled Vehicles. To learn about Ford's perspective on biofuel-related public policy issues, please see Climate Change Policy and Partnerships.

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Compressed Natural Gas (CNG) and Liquefied Petroleum Gas (LPG or propane autogas)

Interest in and use of CNG and LPG, or propane autogas, as a vehicle fuel is expanding, although they still account for a small percentage of vehicle fuels used today.. Supply of CNG and LPG is also growing as new reserves of natural gas are being accessed through non-conventional drilling methods. These fuels also offer some environmental and cost benefits that make them good options for some drivers. CNG and LPG are especially relevant for centrally fueled vehicles, such as government fleets, taxis, delivery trucks, and construction and maintenance fleets.

In the U.S. increasing domestic natural gas production is further reducing prices. This increase in domestic supply, coupled with improved vehicle technologies, is promoting many fleet managers to reconsider using these fuels in their fleets.

In the U.S. CNG is primarily used in heavy-duty vehicles, such as long-haul trucks and buses, and medium-duty vehicles, such as our Ford Super Duty trucks. However, as a result of additional requests from business and fleet customers, Ford also announced plans to offer an F-150 with CNG capability in 2014. LPG is used primarily in medium-duty vehicles and some light-duty vehicles such as taxis.

In Europe, South America and Asia, these fuels are somewhat more widely used. CNG is most widely used in Iran, Pakistan, India, Argentina and Brazil. LPG is most widely used in Turkey, South Korea, Poland, Italy and Australia. Globally, CNG is used in only about 1.3 percent of the total vehicle fleet, while LPG is used in about 3 percent.

CNG- and LPG-fueled vehicles emit less greenhouse gases than comparable gasoline-powered vehicles. Vehicles running on CNG typically emit about 25 percent less CO_2 and about 10 percent fewer total GHGs on a well-to-wheels basis. Vehicles running on LPG typically emit 15 to 25 percent fewer total life cycle GHG emissions. CNG and LPG also reduce non-CO_2 tailpipe emissions such as NOx, SOx, particulate matter and carbon monoxide.

CNG and LPG also have significantly lower fuel costs. CNG costs approximately 40 to 70 percent less than gasoline on a gasoline-gallon equivalent basis depending on location. LPG costs approximately 50 percent less per gallon compared to gasoline. While CNG provides better GHG and fuel costs reductions, LPG can have other benefits. For example, LPG refueling systems typically cost significantly less to install. LPG fuel tanks are also smaller than CNG, resulting in less loss of cargo and/or passenger capacity.

There are some significant challenges to wider adoption of CNG and LPG as vehicle fuels. Though both fuels are widely available in most countries, there is not an established refueling infrastructure for vehicles in most countries. In addition, to provide adequate driving range, both gases must be stored under pressure in the vehicle, requiring larger and heavier tanks that reduce vehicles' passenger and cargo capacity.

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Driver

The "driver" portion of the GHG emissions equation holds the potential for substantial emission reductions at minimal cost, but it is often overlooked. Ultimately, drivers decide which vehicles and fuels they will purchase and how those vehicles will be driven. While our major focus is on the vehicles we make, we have also reached out to drivers around the world to promote the practice of "eco-driving." We do this by providing training, information and vehicle technology that helps drivers learn how to drive using the least fuel possible. We are also facilitating the development of apps and other tools to help drivers track and improve their fuel efficiency. For example, in 2013 we held a Personalized Fuel-Efficiency App Challenge, which resulted in creation of a range of apps to help customers optimize their personal fuel economy performance on the road and share that information with others.

Helping Drivers Improve Fuel Efficiency with Information Technology

Ford's in-vehicle technology system – MyFord Touch® – offers an array of real-time information on fuel-economy performance that can coach drivers to get more miles to the gallon and save on fuel costs. In addition, MyFord Touch's map-based navigation system offers an Eco-Route option that quickly calculates the most fuel-efficient route a driver can take to get from A to B. Ford testing shows that Eco-Route can help achieve fuel economy gains of up to 15 percent. This technology will be available across our full range of vehicles, from affordable small cars to high-end luxury vehicles. It is currently available on the Ford Escape, Explorer, Focus, Fusion, C MAX, Taurus, Edge, Flex, F-150 and Super Duty®. By 2015, approximately 80 percent of Ford's North American models will offer MyFord Touch, with similar percentages predicted for the world market. SYNC was launched in Europe in 2012. It was initially available on the Ford B MAX and is available in now in Fiesta, B MAX, EcoSport, C MAX, Kuga, Transit and Tourneo Custom, Transit and Tourneo Connect, and Transit and Tourneo Courier. SYNC2 will be launched with the new Focus in 2014 and will also be available in the all new Mondeo from late 2014. SmartGauge® with EcoGuide is a dashboard display in the Ford Fusion, C MAX and Lincoln MKZ Hybrids, the Fusion and C MAX Energi plug-in hybrids, and the Focus Electric that gives drivers information to help them maximize fuel efficiency. The system provides information on current fuel economy, fuel economy history, odometer reading, engine coolant temperature, fuel level, battery charge status, electric vehicle mode, tachometer, engine output power, battery output power, power to wheels, engine pull-up threshold and accessory power consumption. Drivers can use the system to track their long-term fuel economy progress and illustrate it either with a traditional chart or using an innovative display of "growing leaves and vines." The more efficient a customer is, the more lush the leaves and vines, creating a visual reward for the driver's efforts. In addition, the real-time system feedback allows drivers to assess and modify their driving habits to achieve maximum fuel economy.

In Europe, we offer the EcoMode system to help drivers maximize their fuel economy. This system monitors the key parameters for optimal fuel consumption that drivers can affect by changing their driving behavior, including gear shifting, anticipation (i.e., driving as consistently and smoothly as possible) and motorway driving (i.e., driving with the most efficient speed on highways and country roads). In addition, the system considers the percentage of cold-engine short trips. Through this monitoring process, Ford EcoMode generates a driver profile with a scoring system for these driving parameters and offers information on how to improve fuel economy over time. This process can be translated into driver advice that can help make the best use of the vehicle's technology. The system is now available in Europe on the Fiesta, B MAX, Focus, C MAX, Kuga, Mondeo, S MAX and Galaxy, as well as the all new Transit/Tourneo Customer and Connect.

Eco-Driving Information and Training

Ford has demonstrated that drivers who practice "eco-driving" can improve their fuel economy by an average of 24 percent. Eco-driving tips are available to the public on Ford's website, and online training is available through the Ford Driving Skills for Life (DSFL) program. In addition, a Web-based eco-driving program has been available to all U.S. salaried Ford employees since 2006.

Ford began work on the eco-driving concept in 2000, when we first offered an eco-driving program through our German dealerships, in partnership with the German Federation of Driving Instructor Association and the German Road Safety Council. That program, which continues today, trains drivers in smarter and greener driving skills and vehicle maintenance habits. It uses specially trained and certified instructors to run programs for several target groups, including fleet drivers and customers. By the end of 2013 more than 17,000 German drivers had been "eco-trained" through this program.

In 2013, Ford continued to support the ECOWILL project, which stands for Eco-Widespread Implementation for Learner Drivers and Licensed Drivers. Ford has been the only automotive industry member active in this project since it began in 2010. This project, which concluded as scheduled in April 2013, was based on the premise that "eco-driving" can reduce CO_2 from motoring and improve road safety without making it less "fun to drive." ECOWILL succeeded in meeting two primary goals:

- A mass roll-out of high-quality/standardized short duration eco-driving trainings. Ford operates one-hour courses with professional driving instructors as part of this goal, and
- Promoting the education and testing of eco-driving for learner drivers in regular driving school under the leadership of EFA, the European driving school association.

Thanks to this project, approximately 32,000 new drivers were "eco-trained," and more than 10,000 already-licensed drivers received this training. The project resulted in many benefits that will continue on after its formal conclusion. For example, the "eco-driving" training developed through this program was added to driver training programs required in all European countries. ECOWILL also influenced the creation of many national eco-driving and road safety initiatives and resulted in a successful eco-driving "coaching" methodology that can be used in other programs.

From 2010 to 2013 Ford also contributed to a European research project called "eCoMove." Through this project, Ford and 32 partner organizations developed and tested vehicle-to-driver communications technologies focused on reducing CO_2 emissions from road transport by reducing inefficiencies in driver behavior. In field tests, the new technologies resulted in a 15 percent improvement in fuel economy and CO_2 emissions. As part of this project, Ford tested an accelerator pedal that provides tactile feedback to the driver and an associated dashboard display that coach drivers on more fuel efficient driving behavior. The system provides drivers with information about approaching road conditions that can help drivers make more efficient driving choices, such as slowing down earlier and more slowly. The system also helps drivers time their speed to reach traffic lights when they will be green to avoid unnecessary stopping and accelerating. This new driver assistance system leverages existing Ford technologies including traffic sign recognition, advanced map information, car-to-car and car-to-infrastructure communications to help drivers prepare for or avoid road congestion and changes in topography.

In Asia Pacific Africa, we launched the Ford DSFL driver training program in 2008. In this region the program places equal emphasis on safe driving and eco-driving, as customers are interested in both. In 2013, Ford DSFL in Asia trained licensed drivers in mainland China, India, Indonesia, Taiwan, Thailand, Vietnam, the Philippines and South Africa. Approximately 14,000 drivers were trained through this program in 2013. More than 77,000 people have been trained since the program began in Asia six years ago.

Non-CO_2 Tailpipe Emissions

Smog-forming vehicle emissions result from the incomplete combustion of fuels, impurities in fuels and the high-temperature oxidation of atmospheric nitrogen during the fuel-combustion process. Regulated smog-forming tailpipe emissions include hydrocarbons, nitrogen oxides (NOx), carbon monoxide and particulate matter.

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In the U.S., smog-forming emissions are regulated by the U.S. Environmental Protection Agency (EPA) under the Clean Air Act as well as by the California Air Resources Board (CARB).

As of 2010, all of Ford's U.S. vehicles have been certified to the EPA's Tier 2 regulations, a comprehensive and challenging set of vehicle emissions requirements.

The Tier 2 program, which began with the 2004 model year, coordinates the introduction of cleaner fuels with more stringent vehicle-tailpipe emissions standards to achieve near-zero non-carbon-dioxide (CO_2) tailpipe emissions from cars and light trucks. These regulations significantly reduce targeted vehicle emissions, including nitrogen oxides and non-methane organic gases, to help reduce the formation of ozone and particulate matter. The Tier 2 regulations apply to all passenger cars, light trucks and medium-duty passenger vehicles. Ford completed implementing Tier 2 emissions requirements on all relevant vehicles in the 2009 model year.

The Tier 2 program has been highly successful at reducing smog-forming emissions from vehicles and improving urban air quality. The EPA estimates that this program has resulted in reductions in oxides of nitrogen emissions (from all relevant mobile sources) of at least 1.2 million tons as of 2010. Our own studies suggest that the emission reduction benefits of modern vehicles that meet Tier 2 standards will continue to increase as older vehicles that were produced before the Tier 2 standards are replaced by modern vehicles.[1]

In 2014, the EPA adopted new Tier 3 standards, which are more stringent motor-vehicle emissions standards for future model years. As part of these new standards, the EPA is also requiring reduction of the sulfur levels in gasoline, which will improve the performance of existing catalyst technology in gasoline vehicles and result in reduction of nitrogen oxides, carbon monoxide and volatile organic-compounds emissions from vehicles. The EPA also has stringent emissions standards and requirements for EPA-defined "heavy-duty" vehicles and engines (generally, those vehicles with a gross vehicle weight rating of between 8,500 pounds and 14,000 pounds). These regulations are relevant to Ford's Super Duty® trucks and some commercial vans. In order to meet the standards for heavy-duty diesel trucks, Ford and most other manufacturers use selective catalytic reduction (SCR) systems, which require periodic customer maintenance. The EPA has issued guidance calling for stringent warning systems and driver inducements to alert motorists to the need for the maintenance of SCR systems.

For the California market, Ford is required to meet the state's stringent Low Emission Vehicle II (LEV-II) emissions requirements for light-duty vehicles. Under the LEV-II program, manufacturers are effectively required to produce a number of Partial Zero Emission Vehicles (PZEV). A PZEV is a vehicle certified to near-zero emissions standards. Strictly speaking, PZEVs are required to:

- meet California's Super Ultra Low Emission Vehicle (SULEV) exhaust emissions standard;
- produce zero fuel-system evaporative emissions; and
- be emissions-compliant for a full useful life of 150,000 miles.

For the 2013 and 2014 model year, Ford offered the Focus Electric ZEV, Focus and Fusion PZEV, as well as plug-in hybrid Enhanced Advanced Technology (AT) PZEV versions of the Ford Fusion and C MAX. In 2012, CARB finalized revisions to its LEV and ZEV regulations. The new LEV-III Program begins to take effect with the 2015 model year and includes more stringent tailpipe and evaporative emissions standards for light- and medium-duty vehicles, extended durability requirements and changes to the certification test procedures, which will require manufacturers to certify vehicles on fuel containing 10 percent ethanol. The amended ZEV regulations mandate substantial annual increases in the production and sale of battery-electric, fuel-cell and plug-in hybrid vehicles for the 2018–2025 model years. By the 2025 model year, approximately 15 percent of a manufacturer's total California sales volume will need to be made up of such vehicles. The LEV-III regulations will also require automobile manufacturers to design and develop new emissions after-treatment systems. Compliance with the 2018–2025 ZEV mandate involves intensive planning efforts and large capital investments in order to deliver the required number of advanced-technology vehicles. We are concerned that the market and infrastructure in California might not support the large volumes of advanced-technology vehicles that manufacturers will be required to produce, particularly in the 2018–2025 model years. We also are concerned about potential enforcement of the ZEV mandate in other states that have adopted California's ZEV program, where the existence of a market for such vehicles is even less certain. We are working with both the EPA and CARB through their regulatory processes to help develop rules that are both effective and feasible. In setting tailpipe emissions regulations, other rules that apply to vehicles – such as fuel economy/greenhouse gas standards and safety standards – must be taken into account to ensure that the total package of requirements is workable.

Ford continues to oppose technology mandates that seek to impose quotas or limits on the production or sale of vehicles with specified powertrain technologies. Regulatory efforts to dictate market outcomes, or to pick technology "winners" and "losers," are typically unsuccessful and characterized by unintended, unwanted consequences. Manufacturers need the flexibility to build the kinds of vehicles that the marketplace demands based on consumer preferences and other external factors. Emissions standards should be performance based and should be designed to enable manufacturers to introduce vehicles with an array of different technologies.

Information about the emissions performance of all Ford vehicles sold in the U.S. can be found at the EPA's Green Vehicles site.

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Europe

Since 1990, we have decreased the non-CO_2 tailpipe emissions from our vehicles sold in Europe by up to 90 percent through the development of a new generation of downsized, high-efficiency gasoline- and diesel-powered vehicles with improved engine technologies and high-tech exhaust gas treatment devices. As part of these emissions-reduction efforts, all of our diesel engines are now fitted with a maintenance-free diesel particulate filter system that requires no additives for filter regeneration.

Further air-quality improvements have been generated as we have introduced vehicles equipped with technology to meet the more stringent Euro 5 emissions standards. We currently offer three variants of our GTDi EcoBoost® engine in Europe: the 1.6 liter, 2.0 liter and the 3-cylinder 1.0 liter. These are among the most technologically advanced engines in production, combining high-pressure direct injection, a low-inertia turbo and twin independent variable cam timing. They join our lineup of high-efficiency common rail diesel engines all complying with Euro 5 emissions levels. In 2012, Ford also launched a new version of the 1.6-liter Ford Duratorq® TDCi engine, featuring the first lean NOx-absorbing technology in a Ford diesel, as well as a completely redesigned common rail injection system to deliver more precise control and increased combustion efficiency. All of our new passenger cars registered as of January 1, 2011, and all light-duty vehicles registered as of January 1, 2012, comply with the Euro 5 standard.

Euro 6 standards have been developed. The initial phase of Euro 6 will be applied beginning in September 2014. The second phase of Euro 6 standards, which will be even more stringent, will be applied beginning in 2017. New test procedures based on consumer driving patterns are also under development by the European Commission and are intended to be finalized during 2013 for use during the implementation of the Euro 6 standards. These new emissions-testing requirements are focused primarily on delivering reduced tailpipe NOx emissions. The European Commission is also developing rules for increasing the severity of the low-temperature testing and evaporative emissions requirements again. The new rules should be finalized during 2013. We are actively engaged with the European Commission and the European member states in developing better regulation.

Even with the significant emissions improvements in modern vehicles, some smog-forming emissions levels remain higher than desired. For example, roadside emissions of NO_2 in some locations exceed the stringent European NO_2 air quality limits. Ford is working with the European Commission and other stakeholders to define a new emissions test procedure that better measures on-road vehicle emissions for the second stage of Euro 6 regulations. Our own air quality simulations predict a significant improvement in roadside air quality as the existing vehicle fleet is replaced with newer, cleaner vehicles and as emissions regulations become increasingly stringent.

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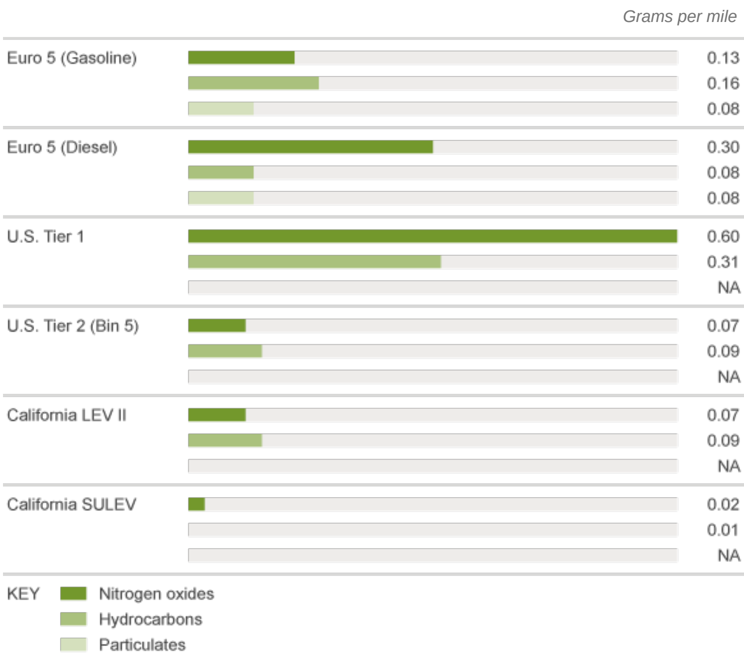
Emissions Regulations in the U.S. and Europe



	Nitrogen oxides	Hydrocarbons	Particulates
Euro 5 (Gasoline)	0.13	0.16	0.08
Euro 5 (Diesel)	0.30	0.08	0.08
U.S. Tier 1	0.60	0.31	NA
U.S. Tier 2 (Bin 5)	0.07	0.09	NA
California LEV II	0.07	0.09	NA
California SULEV	0.02	0.01	NA

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Asia Pacific Africa

Since 2010, our new gasoline-fueled passenger vehicles have been designed to comply with China IV requirements (based on Euro 4 standards). China began implementing more recent European standards (Euro 5) in Beijing in 2013. Korea and Taiwan have adopted very stringent U.S.-based standards for gasoline vehicles and European-based standards for diesel vehicles. Japan, which has unique standards and test procedures, began implementing more stringent standards in 2009. Ford is working to comply with all of these standards using a variety of approaches, including on-board diagnostics and after-treatment technologies.

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South America

New passenger and commercial vehicles in South America must comply with varying levels of U.S.- or European-based emissions regulations. Recently, Brazil, Argentina and Chile have introduced more stringent emissions standards. Brazil approved European Stage 5 (Euro 5) emissions and on-board diagnostic standards for heavy trucks starting in 2012; more stringent light-vehicle limits also came into effect starting in 2012. Argentina also will apply Euro 5 standards beginning in 2015 (for new vehicle homologations) and 2017 (for new vehicle registrations). Chile approved a plan to introduce more stringent emissions standards (i.e., Euro 4 and 5 or corresponding U.S. emissions standards) nationwide for light- and medium-duty vehicles, and progressive alignment with the Metropolitan Region (i.e., the capital city Santiago and surrounding area) by September 2014. Heavy-duty vehicles will be required to meet Euro 5 (or corresponding U.S. emissions standards) by October 2014. As a consequence, the following non-CO_2 emissions-control technologies have been or will be introduced on our vehicles sold in South America: on-board diagnostic systems in Brazil and Argentina (which are being studied for use in Chile); particulate filter technology for some diesel products; and selective catalytic-reduction systems for heavy diesels in all three countries.

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1. T.J. Wallington, J.A. Anderson, S.E. Winkler, “Comment on ‘Natural and Anthropogenic Ethanol Sources in North America and Potential Atmospheric Impacts of Ethanol Fuel Use’”, Environ. Sci. Technol. 47, 2139–2140 (2013).

Sustainable Materials

Materials are an important element of a vehicle's sustainability at all stages of its life cycle. Material selection can influence the safety, fuel economy and performance of the vehicle, as well as opportunities to recycle or reuse the vehicle's components at the end of its life. The materials used in a vehicle can also have implications throughout our value chain. A material can be more or less sustainable based on a number of factors, including its origin (virgin, renewable or recycled), the resources and manufacturing methods used to process it, the emissions produced throughout its life cycle and its application.

Ford has been working for many years to increase the use of recycled and renewable materials and to reduce the use of undesirable materials. Vehicles in North America typically are composed of 20 percent to 25 percent post-consumer recycled material by weight, primarily due to the extensive use of metals with recycled content (see What is in a Vehicle? for detail). Therefore, we have concentrated our efforts on developing new uses for recycled materials in the nonmetallic portions of our vehicles, which are typically composed of virgin materials. While the amount of recycled content in each vehicle varies, we are continually increasing the amount of recycled material used in each vehicle line and have implemented a number of innovative uses of sustainable materials (see Choosing More Sustainable Materials). We use tools such as life cycle assessment and life cycle costing to help us make beneficial materials choices.

Since the early 1990s, Ford has had a Voluntary Recycled Content Usage Policy in North America, which sets targets for the use of nonmetallic recycled content in each vehicle and increases those targets year by year and model by model. Under this program, recycled materials are selected for all of our vehicles whenever technically and economically feasible. We are now developing sustainable materials requirements for new vehicle programs and significantly refreshed vehicle lines to increase the recycled and renewable content, and we are developing specific, numerical, model-over-model improvement targets. We pilot tested vehicle-level recycled content targets with the 2014 F-150. We plan to leverage learnings from that pilot to improve future target-setting processes and expand them across additional vehicle lines in the future.

We are also continuing to introduce successful applications of recycled and renewable content into more vehicles for increased environmental benefit. We are focusing on materials technologies that improve environmental and social performance, and reduce costs and weight. To facilitate this, we are working with our commodity business planners, materials purchasers and materials engineers to develop a comprehensive list of cost-effective sustainable materials that can be implemented across multiple parts and vehicle lines. All recycled and renewable materials on this list are compared with virgin grades to ensure appropriate physical properties and component performance. By combining goals for updated or redesigned vehicles with identification and testing processes, we are standardizing and expanding the use of sustainable materials in our vehicles.

As we introduce sustainable materials, we do not assume that recycled materials are always the best solution. For example, we take into consideration whether recycled materials may increase vehicle weight or have significant energy demand in collection or recycling. We also have to balance our global materials strategy, which has dramatically reduced the number of materials we specify and use in order to maintain consistent quality and enable cost reductions, with the challenges of finding globally common recycled materials and recycled material feedstock. In some cases, the introduction of recycled and renewable materials runs counter to that commonization progress, since the feedstock for these materials can vary by region. For example, it is often more efficient to use materials made from local sources that divert waste from local landfills than to ship recycled-material inputs across the globe. We are working to ensure that we use local materials as a feedstock for our recycled-content materials.

We are developing and implementing an integrated sustainable materials strategy that builds on our voluntary recycling standards and our work to develop and implement more recycled and renewable materials. This strategy includes:

- **Developing guiding principles for incorporating recycled and renewable materials in our vehicles:** We have formed a cross-functional and globally integrated sustainable materials council to guide the sustainable materials strategy for the company. This informal team has developed a set of guiding principles to help us think through choices of materials. These principles, listed below, reflect our collective thinking on the most effective ways to increase the use of recycled and renewable materials in our vehicles:
  - Recycled and renewable materials will be selected whenever technically and economically feasible.
  - Recycled and renewable content will be increased year over year and model by model. Product quality, durability, weight, performance (material specification and/or part design verification) and economics will not be adversely impacted by the use of recycled and renewable content materials.
  - Tools and enablers will be provided to select, specify, track and validate the use of recycled and renewable materials.
  - Recycled and renewable materials will be used where there is evidence of reduced or improved life cycle impact.
  - Recycled materials will be used primarily in the market of origin, to minimize the carbon footprint.
  - Renewable content sourcing shall not compete with the food supply. Sustainable supply must be ensured (in terms of stable supply and sustainable growth).

- **Integrating recycled and renewable materials into the official strategies that govern materials and commodities purchasing:** We are developing global materials specifications that include recycled material specifications to facilitate greater use of these materials. Many commodity-purchasing plans already list recycled-content materials as a preferred material option, including those for battery trays, battery shields and wheel-arch liners. In addition, we developed a comprehensive resin strategy that requires the use of recycled plastics for underbody and aerodynamic shields, fender liners, splash shields, stone-pecking cuffs and radiator air-deflector shields manufactured in North America.

In other cases, we are adding recycled-content materials into our material-specification documents where we have found the recycled materials meet our rigorous performance requirements. This makes it easier for component engineers and Tier 1 suppliers to choose sustainable materials by providing a direct comparison of their performance characteristics with an equivalent virgin material.

We have also developed a material specification that defines *post-consumer*, *post-industrial* and *depolymerized recycled content* and ensures that the use of in-house scrap is not counted toward recycling targets. We are also working on specifications for renewable materials to make it easier for product engineers to incorporate renewable materials where we have found that they meet our performance standards.

Climate Change and the Environment

- Overview
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- **Greening Our Products**
  - Life Cycle Analysis
  - Sustainable Technologies and Alternative Fuels Plan
  - Vehicle Fuel Efficiency and CO_2 Emissions Progress and Performance
  - Non-CO_2 Tailpipe Emissions
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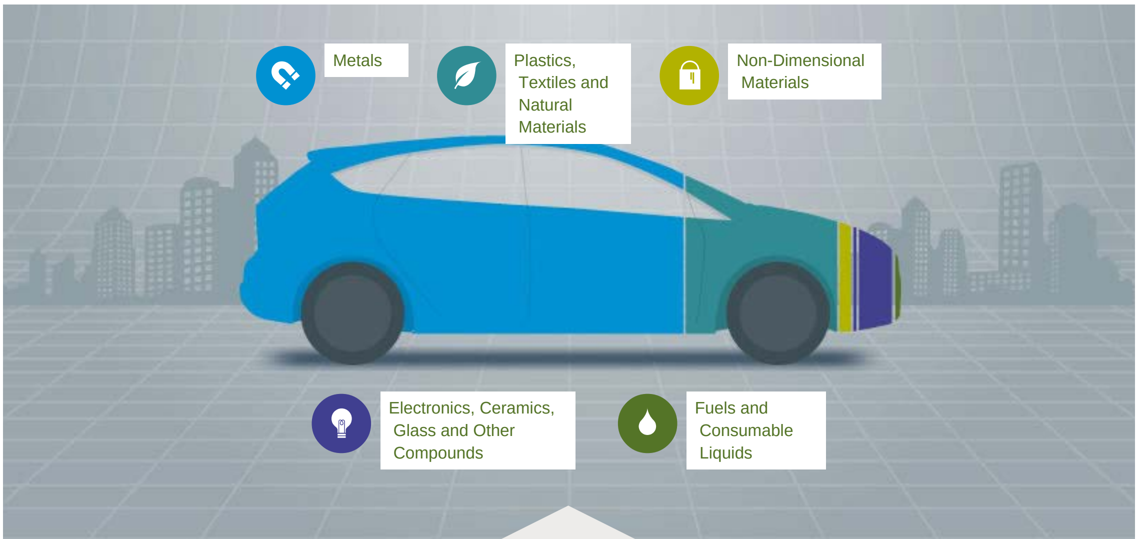
    - End of Life
  - Electrification: A Closer Look
- Greening Our Operations
- Data
- Case Study: Ford Fleet Purchase Planner
- Voice: John Fleming

What is in a Vehicle?



As automobiles have become more sophisticated and capable, they have also become more complex. A typical modern vehicle might contain up to 10,000 different parts made of about 1,000 different types of materials, that in turn are made from about 10,000 different chemical substances. To understand our approach to sustainable materials, it is useful to understand the kinds and amounts of materials that are in our vehicles. The graphic above shows the primary materials categories used in our vehicles. Click on each material category to read more about those materials, the approximate amounts used in our vehicles, and our sustainable-material strategy.

Metals

Most vehicles are made of at least 75 percent metals by weight. While the metals in today's vehicles are primarily steel and iron, we are working to increase the use of lightweight metals such as aluminum, magnesium and titanium. By replacing iron and steel with these metals, we can reduce the total weight of the vehicle and therefore help improve vehicle fuel economy. However, we use life cycle analysis tools to ensure that when we use lighter materials, like aluminum, we end up with net life cycle energy and CO_2 benefits. (For more information, see the Lightweight Materials section.) Because all metals are routinely recycled at the end of a vehicle's useful life, we focus most of our sustainable materials efforts on nonmetallic parts.

Ford Ranger
79% metals

Ford Fiesta
76% metals

Ford Fusion
76% metals

Ford Edge
76% metals

Plastics, Textiles and Natural Materials

Ford Ranger
17% plastics, textiles and natural materials

Ford Fiesta

These materials are the primary focus of our sustainable materials efforts. Though they make up a much smaller percentage by weight of the average vehicle than metals, they are the second-largest category in most vehicles. Increasing the amount of recycled content in these materials diverts waste from landfills. Increasing the amount of renewable content in these materials can reduce our dependence on finite resources and reduce life cycle greenhouse gas emissions. We are using a wide range of recycled-content plastics and renewable, plant-based materials in our vehicles. (For more information, see Choosing More Sustainable Materials.)

19% plastics, textiles and natural materials

Ford Fusion

18.5% plastics, textiles and natural materials

Ford Edge

18% plastics, textiles and natural materials

Non-Dimensional Materials

These are materials such as paint, adhesives and sealants that have no shape or "dimension" before they are incorporated into a vehicle. Many non-dimensional materials have been a traditional source of volatile organic compound (VOC) emissions during the vehicle manufacturing process. We are taking steps to replace VOC-emitting materials with alternatives or change our processes to reduce or recapture VOC emissions. (For more information, see Non-CO_2 Facilities-Related Emissions.)

Ford Ranger

1% non-dimensional materials

Ford Fiesta

1% non-dimensional materials

Ford Fusion

1.3% non-dimensional materials

Ford Edge

1% non-dimensional materials

Electronics, Ceramics, Glass and Other Compounds

Ford has been working with our suppliers, dealers, dismantlers and industry associations (such as the United States Council for Automotive Research (USCAR) Vehicle Recycling Partnership) to develop, share and implement best practices to deal with these categories of materials, which are a small percentage of any given vehicle by weight but are hard to recycle at the end of the vehicle's life. Dealers and dismantlers are encouraged to reuse or recycle these materials whenever it is technically and economically feasible, to help divert them from landfills. Ford seeks to keep these materials to less than 5 percent of our vehicles, to maintain an overall vehicle recoverability rate of 95 percent.

Ford Ranger

0.2% electronics

2.3% ceramics, glass and other compounds

Ford Fiesta

0.5% electronics

3% ceramics, glass and other compounds

Ford Fusion

0.2% electronics

3.5% ceramics, glass and other compounds

Ford Edge

0.2% electronics

4% ceramics, glass and other compounds

Fuels and Consumable Liquids

These materials include the gasoline in the tank, engine oil, lubricants and other liquids. They are generally removed at dismantlers and recycled/reused where possible.

Ford Ranger

0.5% fuels and consumable liquids

Ford Fiesta

0.5% fuels and consumable liquids

Ford Fusion

0.5% fuels and consumable liquids

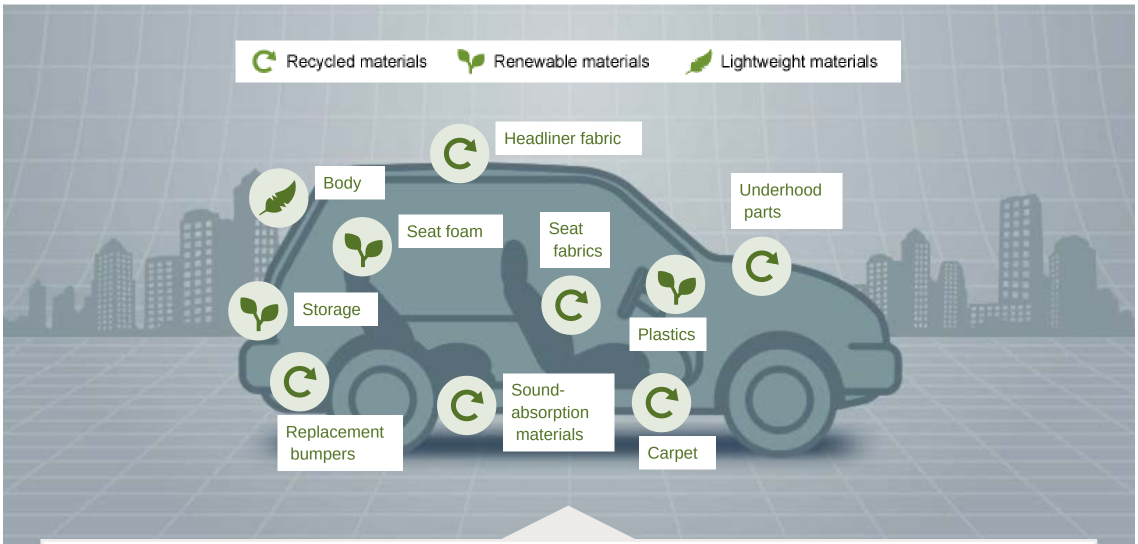
Ford Edge

0.8% fuels and consumable liquids

Choosing More Sustainable Materials

On this page

- Recycled Materials
- Renewable Materials
- Lightweight Materials



Click on the vehicle parts above to read more about sustainable materials we're using in our vehicles.

Carpet

Recycled-content carpets are used in many vehicles, including the U.S. and European Ford Focus, the 2012 North American Fiesta and the 2013 Escape and Explorer.

Replacement bumpers

Many European vehicles use recycled plastic replacement bumpers when original bumpers are damaged.

Seat fabrics

Seat fabrics in versions of the Ford Fiesta, Taurus, Mustang, Focus, F-150, Super Duty®, Fusion, Flex, Escape and Explorer contain 25 percent to 100 percent recycled content.

Seat foam

Since 2011, all vehicles manufactured in North America have used seat foam made with soy oil, which reduces carbon dioxide (CO_2) emissions and decreases dependence on petroleum oil.

Body

High-Strength Steels

Many vehicles – including the all-new Ford Fusion, the Explorer and the European Fiesta – use high-strength steels, which weigh less than traditional steels but have the same or better performance.

Aluminum and Magnesium

Many vehicles use aluminum and magnesium parts, which are lighter in weight than traditional steel, resulting in better overall vehicle fuel economy.

In 2014 we will introduce an all-new F-150, which makes extensive use of high-strength steels and aluminum. For more information on this vehicle, please see our F-150 case study.

Headliner fabric

In North America, the 2012 Ford Fiesta, 2013 Econoline and 2013 Super Duty use 50 percent to 75 percent recycled content in the headliner fabric.

Underhood parts

Recycled plastics and nylon are used in non-surface parts on many vehicles; these parts may include fan shrouds, battery trays, heater/air-conditioning housing, wheel-arch liners, engine fans and covers, and underbody systems.

Sound-absorption materials

Recycled denim scrap from apparel production is used in sound-absorption materials on many vehicles, including the 2012 Ford Focus.

Storage

Injection-molded plastics reinforced with renewable wheat straw were implemented in the third-row storage bins on the Ford Flex. Wheat straw is a byproduct of growing wheat, and is commonly burned. Using this material as a reinforcement in plastics has environmental benefits.

Plastics

Ford vehicles use a range of innovative, natural-fiber-reinforced plastics. For example, in Europe, the Ford Mondeo uses plastics made with 50 percent kenaf and 50 percent polypropylene. In North America, a kenaf-reinforced armrest is used on the 2012 Ford Escape and a coconut-fiber trunk liner is used on the 2012 Focus Electric.

We are working to improve the sustainability of our vehicles by using materials that are more sustainable from a total life cycle perspective. This includes increasing the use of recycled, renewable, recyclable and lightweight materials. Recycled materials incorporate post-consumer and/or post-industrial waste materials; renewable materials are made from plant-based materials; and lightweight materials use special materials and/or designs that provide the same or better performance as other alternatives with less weight.

Recycled Materials

Recycled materials do not mean low-quality materials. Our researchers work to ensure that post- industrial and post-consumer recycled-plastic materials have the same level of quality and same material specifications as the virgin material parts. In some cases, we are working to recycle the materials from our auto parts right back into the same use. For example, we are developing methods for recycling and cleaning post-industrial recycled fascia and bumper scrap so that it can be molded into new fascias and bumpers. We are even working to "upcycle" certain materials – that is, recycle it into uses with higher material and performance requirements than the virgin material. For example, we are working on upcycling post-consumer laundry detergent containers and milk bottles into blow-molded automotive components. In addition, we are developing a method to recycle polyurethane foam scrap to make new polyurethane foam components instead of landfilling it at the end of its life. In Europe, we will soon launch vehicles that use upcycled post-consumer drinking bottles for energy-absorbing materials.

This section describes our efforts to include recycled content in our vehicles, and to recycle parts removed from our vehicles during vehicle servicing.

Using Recycled Materials in "Nonvisible" Parts

Our efforts to increase recycled materials focus on nonmetallic parts, which historically have had little or no recycled content. We recently updated our global sustainable materials strategy, which stipulates that a wide range of parts on vehicles be made out of plastics from post-consumer recycled waste, such as beverage bottles, tires and automotive battery casings. The vehicle parts containing recycled content include underbody and aerodynamic shields, fender liners, splash shields, stone-pecking cuffs, battery-housing covers and base plates, wheel-arch liners, heating and ventilation components, fan shrouds and powertrain undershields, and fabric rear-wheel liners. Our global sustainable materials strategy saves money and reduces landfill waste. We estimate that in North America alone, Ford saves approximately $10 million per year by using recycled materials.

Most of our recycled-content parts are made of at least half-recycled materials. For example, many underbody and underhood plastic parts are made from 75 percent recycled batteries and 8 percent recycled high-density polyethylene (HDPE) bottles. Most of the underbody molded and/or masticated rubber parts we use in North America are made from blends of recycled polypropylene and car tires, and contain 75 percent to 90 percent post-consumer recycled content. We use more than 50 million pounds of post-consumer recycled materials on the exterior of Ford vehicles made in North America, which translates to more than 17.8 pounds per vehicle on average across our North American fleet.

These parts not only increase our use of recycled materials, they can also have additional benefits. For example, fabric rear-wheel liners, which contain 30 percent to 40 percent recycled content, are 50 percent lighter than plastic wheel liners, and they absorb sound, which potentially reduces the need for sound-deadening insulators, sprays and foams. We continue to expand the use of recycled plastics into additional parts where they meet performance and cost requirements.

We are using post-consumer recycled nylon in many underhood parts, including air-cleaner housings, engine fans, fan shrouds, HVAC temperature valves, engine covers, cam covers and carbon canisters. We are using nylon resin made from recycled carpets for cylinder head covers in the Ford Escape, Fusion, Mustang and F-150.

Using Recycled Materials in Visible Interior Applications

Across our global operations, we are also using recycled materials for interior parts, where it can be much more challenging to achieve the necessary appearance and performance than using recycled materials for underbody, subsurface and exterior black parts. We are continuing to expand our use of recycled seat fabrics and seat components that meet all appearance and performance requirements.

Since the 2009 model year, the seat fabrics in most of our new or redesigned North American vehicles have been made from at least 25 percent post-industrial or post-consumer recycled content. Thirty-seven different fabrics meeting the requirements have been developed and incorporated into Ford vehicles. In addition, many of our non-woven headliner fabrics now contain 50 percent to 75 percent recycled yarns, depending on the color.

Ford is the first automaker to use REPREVE® – a hybrid fiber made from recycled plastic water bottles and post-industrial waste – for seating fabric. This fiber, which was introduced on the 2012 Ford Focus, is being used on the 2013 and 2014 Ford Focus, 2013 and 2014 Ford Fusion, the 2014 Ford Edge, and the 2015 Ford Mustang and Ford F-150. Approximately 22 plastic, 16-ounce water bottles are used to make the seat fabric in a Focus; approximately 39 such bottles are used for seats in the Fusion S and SE; and between 63 and 110 such bottles are used for the F-150, depending on the model. The following table highlights some of the recycled-content interior materials in our recent vehicles:

Vehicle	Material	Partner	Benefits
2015 Mustang Base Series	Seat fabric bolster: 54 percent recycled content from post-consumer and post-industrial recycled yarns	Sage Automotive Interiors, Unifi	▪ Reduces consumer and industrial waste ▪ Reduces depletion of natural resources ▪ Reduces energy consumption ▪ Uses closed-loop system for recycling manufacturing waste
	Seat fabric insert: 38 percent recycled content from post-industrial recycled yarns	Sage Automotive Interiors	▪ Reduces waste ▪ Reduces depletion of natural resources
2015 Ford Mustang I4/GT Series	Seat fabric insert & bolster: 54 percent recycled content from post-consumer and post-industrial recycled yarns	Sage Automotive Interiors, Unifi	▪ Reduces consumer and industrial waste ▪ Reduces depletion of natural resources ▪ Reduces energy consumption ▪ Uses closed-loop system for recycling manufacturing waste
2015 Ford F-150 XL Series	Seat fabric insert bolster: 54 percent recycled content from post-consumer and post-industrial recycled yarns	Sage Automotive Interiors, Unifi	▪ Reduces consumer and industrial waste ▪ Reduces depletion of natural resources ▪ Reduces energy consumption ▪ Uses closed-loop system for recycling manufacturing waste
	Seat fabric insert: 25 percent recycled content from post-industrial recycled yarns	Aunde	▪ Reduces waste ▪ Reduces depletion of natural resources
2015 Ford F-150 XLT Series	Seat fabric bolster: 33 percent recycled content from post-consumer and post-industrial recycled yarns	Sage Automotive Interiors, Unifi	▪ Reduces consumer and industrial waste ▪ Reduces depletion of natural resources ▪ Reduces energy consumption ▪ Uses closed-loop system for recycling manufacturing waste
	Seat fabric insert: 66 percent recycled content from post-consumer and post-industrial recycled yarns	Sage Automotive Interiors, Unifi	▪ Reduces consumer and industrial waste ▪ Reduces depletion of natural resources ▪ Reduces energy consumption ▪ Uses closed-loop system for recycling manufacturing waste
2015 Ford F-150 Sport Series	Seat fabric bolster: 33 percent recycled content from post-consumer and post-industrial recycled yarns	Sage Automotive Interiors, Unifi	▪ Reduces consumer and industrial waste ▪ Reduces depletion of natural resources ▪ Reduces energy consumption ▪ Uses closed-loop system for recycling manufacturing waste
	Seat fabric insert: 25 percent recycled content from post-industrial recycled yarns	Aunde	▪ Reduces waste ▪ Reduces depletion of natural resources
2014 Ford Edge SE Series	Seat fabric bolster: 100 percent recycled content from post-consumer and post-industrial recycled yarns	Sage Automotive Interiors, Unifi	▪ Reduces consumer and industrial waste ▪ Reduces depletion of natural resources ▪ Reduces energy consumption ▪ Uses closed-loop system for recycling manufacturing waste
	Seat fabric insert: 38 percent recycled content from post-industrial recycled yarns	Sage Automotive Interiors	▪ Reduces waste ▪ Reduces depletion of natural resources
2014 Ford Edge SEL Series	Seat fabric bolster: 100 percent recycled content from post-consumer and post-industrial recycled yarns	Sage Automotive Interiors, Unifi	▪ Reduces consumer and industrial waste ▪ Reduces depletion of natural resources ▪ Reduces energy consumption ▪ Uses closed-loop system for recycling

			manufacturing waste
	Seat fabric insert: 25 percent recycled content from post-industrial recycled yarns	Aunde	▪ Reduces waste ▪ Reduces depletion of natural resources
2014 Ford Edge Sport Series	Seat fabric insert: 100 percent recycled content from post-consumer recycled yarns	Miko Fabrics	▪ Reduces waste ▪ Reduces energy required for yarn manufacturing by 64 percent and manufacturing-related CO_2 emissions by 60 percent ▪ Uses only neutral, nontoxic dyes and no harmful solvents in the fabric manufacturing process
2015 Ford Mondeo (European version)	Seat fabric insert: 37 percent from post-industrial yarns Seat fabric bolster: 43 percent recycled content from post-industrial yarns	Sage Automotive Interiors, Unifi	▪ Reduces consumer and industrial waste ▪ Reduces depletion of natural resources ▪ Reduces energy consumption ▪ Uses closed-loop system for recycling manufacturing waste
2013 Ford C MAX (North America)	Seat fabric (S/SE models): 27 percent post-industrial and post-consumer recycled yarns	JCI/Thierry	▪ Reduces industrial and consumer waste ▪ Reduces waste, water and CO_2 emissions
2013 Ford Escape (North America)	Carpet: 100 percent recycled content from post-consumer and post-industrial recycled yarns	Reiter	▪ Uses material from approximately 25 20-ounce plastic bottles for each Escape
	Seat fabric (S/SE models): 27 percent post-industrial and post-consumer recycled yarns	JCI/Thierry	▪ Reduces industrial and consumer waste ▪ Reduces waste, water and CO_2 emissions
2013-14 Ford Fusion S and SE Series	Seat fabric bolster: 100 percent recycled content from post-consumer and post-industrial recycled yarns Seat fabric insert: 37 percent recycled content from post-consumer and post-industrial recycled yarns	Sage Automotive Interiors, Unifi	▪ Reduces consumer and industrial waste ▪ Reduces depletion of natural resources ▪ Reduces energy consumption ▪ Uses closed-loop system for recycling manufacturing waste
2013-14 Ford Fusion Hybrid and Sport Series	Seat fabric: 100 percent recycled content from post-consumer and post-industrial recycled yarns	Sage Automotive Interiors, Unifi	▪ Reduces consumer and industrial waste ▪ Reduces depletion of natural resources ▪ Reduces energy consumption ▪ Uses closed-loop system for recycling manufacturing waste
2012 Ford Focus Electric	Seat fabric: 100 percent recycled content from post-consumer and post-industrial recycled yarns	Unifi, Sage Automotive Interiors	▪ Uses material from approximately 22 recycled plastic bottles in each vehicle ▪ Reduces consumer waste to landfill ▪ Reduces depletion of natural resources
2011-12 Ford Fiesta (North America)	Seat fabric: 25 percent post-consumer recycled yarns	Aunde	▪ Reduces consumer waste ▪ Reduces depletion of natural resources
	Nonwoven headliner: 75 percent post-consumer recycled yarns	Freudenberg	▪ Reduces consumer waste ▪ Reduces depletion of natural resources
	Carpet: 100 percent recycled content from post-consumer and post-industrial recycled yarns	Peltzer	▪ Reduces waste, energy consumption and depletion of natural resources
2011-13 Ford Explorer XL and XLT	Seat fabric insert: 25 percent to 30 percent post-industrial recycled yarns Seat fabric bolster: 30 percent post-industrial recycled yarns	Aunde, Guilford	▪ Reduces waste, water and energy consumption and depletion of natural resources
	Carpet backing (base series): carpet insulation 40 percent post-industrial recycled yarns Carpet backing (limited series): carpet insulation 25 percent to 28 percent post-industrial recycled yarns	IAC	▪ Reduces energy consumption by at least 20 percent ▪ Reduces waste by at least 17 percent ▪ Reduces CO_2 emissions by at least 14 percent ▪ Reduces water use by at least 9 percent
2011-13 Ford Econoline	Headliner fabric: 50 percent to 75 percent post-consumer recycled content	Freudenberg	▪ Reduces consumer waste ▪ Reduces depletion of natural resources
2011-13 Ford Super Duty	Headliner fabric: 50 percent to 75 percent post-consumer recycled content	Freudenberg	▪ Reduces consumer waste ▪ Reduces depletion of natural resources
	Seat fabric insert: 25 percent post-industrial recycled yarns	Sage Automotive Interiors, Guilford, Aunde	▪ Reduces waste ▪ Reduces depletion of natural resources

	Seat fabric bolster: 30 percent post-industrial recycled yarns		
2010-13 Ford Taurus SHO	Seat fabric insert: 100 percent post-consumer recycled yarns	Miko Fabrics	▪ Reduces waste ▪ Reduces energy required for yarn manufacturing by 64 percent and manufacturing-related CO_2 emissions by 60 percent ▪ Uses only neutral, nontoxic dyes and no harmful solvents in the fabric manufacturing process
2010-13 Ford Taurus SEL	Seat fabric insert: 25 percent post-industrial recycled yarns Seat bolster fabric: 30 percent post-industrial recycled yarns	Aunde	▪ Reduces waste ▪ Reduces depletion of natural resources
2010-2014 Mustang Base Series	Seat fabric insert: 18 percent post-industrial recycled yarns Seat bolster fabric: 30 percent post-industrial recycled yarns	Sage Automotive Interiors, Guilford	▪ Reduces waste ▪ Reduces depletion of natural resources
2010-13 Ford F-150 XL, XLT & FX4	Seat fabrics: 25 percent post-industrial recycled yarns FX4 model seat fabrics are 18 percent post-industrial yarns	Sage Automotive Interiors, Guilford, Aunde	▪ Reduces waste ▪ Reduces depletion of natural resources
2013 Ford Flex SE and SEL Series	Seat fabric insert: 35 percent post-industrial recycled yarns	Sage Automotive Interiors, Aunde	▪ Reduces industrial waste ▪ Reduces depletion of natural resources ▪ Reduces energy consumption
2013 Ford Fusion S and SE Series	Seat fabric bolster: 100 percent post-consumer and post-industrial recycled yarns Seat fabric insert: 37 percent post-consumer and post-industrial recycled yarns	Sage Automotive Interiors, Unifi	▪ Reduces consumer and industrial waste ▪ Reduces depletion of natural resources ▪ Reduces energy consumption ▪ Uses closed-loop system for recycling manufacturing waste
2013 Ford Fusion Hybrid and Sport Series	Seat fabric: 100 percent post-consumer and post-industrial recycled yarns	Sage Automotive Interiors, Unifi	▪ Reduces consumer and industrial waste ▪ Reduces depletion of natural resources ▪ Reduces energy consumption ▪ Uses closed-loop system for recycling manufacturing waste

Recycling Parts Removed During Vehicle Servicing

In Europe, we are recycling damaged parts collected by dealers. In the U.K., we are recycling bumpers that have been damaged in accidents or replaced in service. Ford dealers collect the bumpers, which are recycled into new bumpers and other plastic parts. Previously, dealers had to pay to dispose of these bumpers as waste. In the U.S., 2013 marked the 10-year anniversary of our Core Recovery Program, through which we have been reusing and recycling parts removed at dealership service centers for use in the production of new Ford vehicles. We have continually expanded the number of parts that we reuse or recycle through this program. The program works similarly to bottle-recycling programs available in many U.S. states. Ford dealership service centers are charged a fee when they order a new part from Ford, but this fee is refunded if the dealer recycles the old part through the Core Recovery Program. When we collect a part from a dealership, we determine whether it is fit for refurbishment and placement into a new Ford vehicle. Parts that can be remanufactured are cleaned, machined and tested to meet Ford quality standards before being used in new Ford vehicles. If a part cannot be remanufactured, we send it to a third party where it is broken down into small pellets that are eventually shipped back to Ford for use in the new-vehicle manufacturing process. During the last 10 years, the program has saved approximately 120 million pounds of vehicle waste from being buried in landfills or being sent to junkyards. In addition to reducing waste, this program has also saved Ford money.

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Renewable Materials

Ford Motor Company has a long tradition of developing and using plant-based materials, which started with the company's founder, Henry Ford. Mr. Ford passionately believed in a partnership between industry and agriculture, each using the products of the other. In the 1940s, Ford vehicles used soybean oil in plastic body panels and paint, as well as wheat-straw-reinforced steering wheels. We continue this legacy today through an active renewable materials research and product development program. Ford is a recognized leader in bringing high-performance, durable, plant-based materials to millions of vehicles every year. The average Ford vehicle uses between 20 pounds and 40 pounds of renewable materials, depending on the vehicle size class. Almost 300 parts used across Ford's vehicles are derived from sources such as soybeans, cotton, wood, flax, hemp, jute and natural rubber.

Using renewable materials in our vehicles has many environmental, economic and performance benefits. For example:

- Reduced carbon dioxide (CO_2) emissions
- Reduced vehicle weight, resulting in improved fuel efficiency and lower vehicle emissions
- Reduced use of petroleum and lower dependence on foreign oil
- Creation of new markets for agricultural products and additional revenue streams for farmers
- Reduced manufacturing energy requirements
- Reduced commodity and manufacturing costs

In 2013, we introduced several new renewable materials in Ford vehicles, all of which resulted from extensive internal research and partnerships with material experts in multiple industries. For example:

- A new composite plastic material reinforced with rice hulls was introduced in the wire harness of the 2014 Ford F-150. The rice hulls, which are a by-product of rice grains, are sourced from farms in the U.S.
- An industry first application of cellulose-reinforced plastic was introduced in the 2014 Lincoln MKX. This material, developed with Weyerhaeuser and Johnson Controls, is being used to replace fiberglass reinforcement in the center console. The cellulose fibers in this composite come from sustainably grown and harvested trees, and related by-products. The material reduces weight by approximately 6 percent and has a smaller carbon footprint than the glass-fiber reinforced plastic it replaces.
- A demonstration vehicle with interior fabrics using The Coca-Cola Company's PlantBottle® technology, which produces a plastic made from 30 percent plant-based materials. Ford researchers worked with Coca-Cola to adapt this technology, formerly only used in plastic packaging, for use in vehicle fabrics. The material was used for the seat fabric, headliner and door-panel inserts of a Fusion Energi plug-in hybrid vehicle. If PlantBottle interior fabrics were migrated across the majority of Ford's U.S. models, it would displace nearly 4 million pounds of petroleum-derived materials and save the equivalent of 295,000 gallons of gasoline and 6,000 barrels of oil.

Some of our other key renewable materials activities are described below.

Soy-Foam and Soy-Oil Applications

In 2007, Ford was the world's first automaker to implement soy-based foam in seat cushions and seat backs. Since 2011, all Ford vehicles built in North America have soy foam in their seat cushions and backs. In addition, 75 percent of headrests produced in North America have soy foam, and the headliner on the Ford Escape is made from soy-based foam.

Ford currently has soy-foam seats in more than 15 million vehicles on the road, which reduces petroleum oil usage by more than 5 million pounds annually. Life cycle analyses that compare soy foams with traditional petroleum-based foams show a net decrease of 5.5 pounds of CO_2 per pound of soy oil used. Ford's use of soy foam reduces our annual CO_2 emissions by 20 million pounds – the annual equivalent of emissions from more than 1,500 typical American households. In addition, using soy foam decreases dependence on petroleum and increases the use of renewable agricultural commodities. Soy foam also offers the potential for cost savings as well as insulation from petroleum product price swings.

We continue to investigate new applications for soy foam, such as for underhood and energy-absorbing foams.

Ford and our supplier partner Recycled Polymeric Materials (RPM) continue to expand the use of new **"green" seals and gaskets** that incorporate both renewable soybean oils and post-consumer, recycled tires. This material is currently used in eight of our vehicle lines, including the Ford Focus, Fusion, Flex and Taurus. In 2013, the use of these greener gaskets and seals diverted approximately 112,000 pounds of used tires from landfills and has used approximately 64,000 pounds of soybean oil.

We have introduced **plant-based castor oil** foam in the instrument panel of the 2012 Ford Focus and 2013 Ford Escape. The castor-oil foam, which includes more than 10 percent renewable content, provides a more sustainable interior foam solution than petroleum-based foam. It also reduces scrap due to improved flow and processing characteristics, is more durable than the materials it replaces, and reduces production time by more than 40 percent.

Natural Fiber Reinforced Plastics

We use renewable, natural-fiber materials to reinforce plastic and for other applications in vehicles. As described above, we introduced cellulose-reinforced plastic in the 2014 Lincoln MKX, the first application of this material in our industry, and new rice-hull-reinforced plastics in the wire harness of the 2014 Ford F-150. Other examples of natural-fiber materials in our vehicles include:

- **Lignotech**, a compression-molded polypropylene and wood material used in the door panels of the European Ford Focus and Fiesta.
- **Kenaf**, a tropical plant is used to reinforce compression-molded plastic in door parts. The Ford Mondeo and Escape use a mixture of 50 percent kenaf and 50 percent plastic in the interior door panels. The use of kenaf reduces the weight of the door bolsters by 25 percent, which translates into better fuel efficiency.
- **Wheat-straw-reinforced plastic** is used in the storage bins of the Ford Flex — the world's first application of this material. The use of wheat-straw-reinforced plastics in the Flex reduces our petroleum usage by some 20,000 pounds and our CO_2 emissions by about 30,000 pounds annually.

Developing Future Renewable Materials

We continue to actively research and develop new renewable materials and applications at Ford's research centers around the world, and through partnerships with automotive suppliers and non-automotive partners. Some of our key research partnerships are outlined below.

- We are continuing to work with the Plant PET Technology Collaborative (PTC), a partnership with The Coca-Cola Company, H.J. Heinz Company, NIKE and Procter & Gamble to accelerate the development and use of 100 percent plant-based PET materials. The overall goals of the partnership are to research and develop commercial solutions for PET plastic made entirely from plants, and to drive the development of common methodologies and standards for the use of plant-based plastic, including life cycle analyses and universal terminology.
- Ford has forged a new partnership with the World Wildlife Fund along with The Coca-Cola Company, Danone, H.J. Heinz Company, Nestle, NIKE, Procter & Gamble and Unilever to launch the Bioplastic Feedstock Alliance (BFA). As the BFA's only automaker, Ford will work alongside other member brands to drive environmentally responsible, socially beneficial and economically viable production of bioplastic feedstock. Through the Alliance, Ford will strengthen its long-standing commitment to the environment by advancing research and development of bioplastics for use across its vehicle lineup.
- In conjunction with Ohio State University, Ford Research has initiated a project to develop sustainable sources of materials to replace synthetic rubber. We are looking at two sources – dandelion root and guayule (a plant grown in the Southwest U.S.) – as possible replacements for natural and synthetic rubber in our plastic and rubber parts. Ford is continuing to participate in a university- and industry-based collaborative effort called the Program of Excellence in Natural Rubber Alternatives, which we joined in 2012, to investigate and develop new technologies related to alternative sources for rubber and latex.
- Ford has also pioneered the use of modified soy oil in synthetic rubber, as a replacement for petroleum oil. This uses a Ford-patented technology to replace part of the petroleum oil with soy or modified soy oil in rubber formulations. It does not affect the base rubber material. Through funding provided by the United Soybean Board, Ford scientists have been researching the use of renewable oils in rubber formulations. Soy-based rubber parts – such as radiator deflector shields, air baffles, cup-holder inserts and floor mats – are under consideration for future Ford vehicle programs.

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Lightweight Materials

We are actively pursuing the development and use of cutting-edge materials – including high-strength steels, lightweight metals such as aluminum and magnesium, and composite materials – to reduce the weight of our vehicles and improve their fuel economy without compromising safety or performance. For example, in 2014 we will introduce an all-new F-150 that makes extensive use of high-strength steels and aluminum. For more information on our use of lightweight materials, please see Weight Reductions in the Sustainable Technologies and Alternative Fuels plan section.

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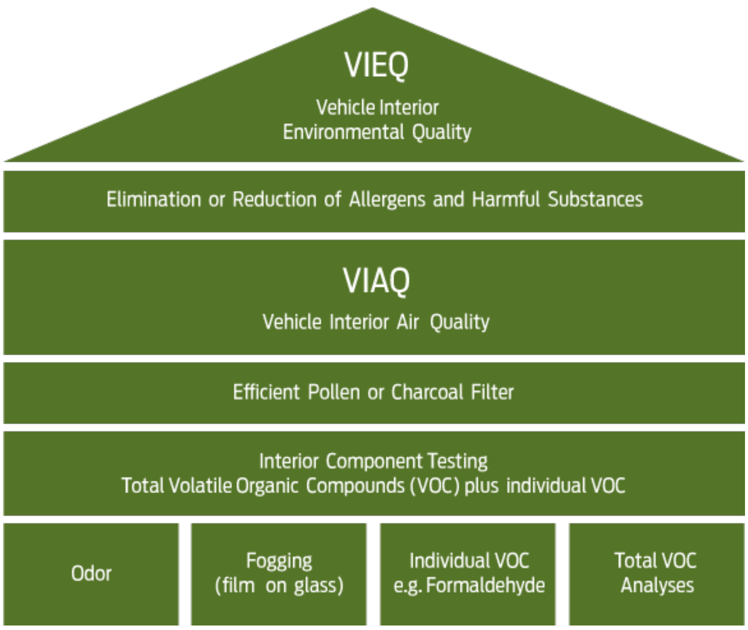
Improving Vehicle Interior Environmental Air Quality and Choosing Allergy-Tested Materials

As part of our effort to deliver vehicles that are safe, green, smart and high quality, Ford is proactively addressing society's growing concern about vehicle interior environmental quality, including air quality and allergens. Consistent with our One Ford global integration plan, a global cross-functional team at Ford focuses on selecting interior materials to reduce allergens and volatile organic compounds. This team is committed to investigating and developing comprehensive global approaches and strategies to address issues relating to vehicle interior air quality. The team has established global design guidelines for materials and filtration, and is migrating those guidelines across Ford's product lines.

We are developing a set of vehicle interior air quality (VIAQ) specifications that require the consideration of the air quality and allergen impacts of the materials and components in our vehicles. Under this standard, engineers test materials used on components with direct skin contact for allergy issues. The complete VIAQ standards include requirements for fogging, odor, aldehydes, substances of concern, total carbon at the component level and air filtration. Many vehicles are also equipped with high-performance pollen filters to prevent allergenic pollens from entering the vehicle. Initially, the requirements were applied to European-based vehicles, and we are now phasing them into the U.S. We plan to implement them in our South American and Asia Pacific Africa operations in the future.

Looking ahead, we continue to monitor emerging requirements in all regions, and anticipate challenges with material selection, testing and development.

The following graphic shows our overall approach to improving vehicle interior environmental quality, including our allergen and VIAQ specifications.



Looking ahead, we are researching ways to use in-vehicle communication systems to help drivers monitor and maintain their own health and wellness. We want to change the paradigm that in-car connectivity systems such as SYNC® can only be used for information and entertainment purposes. We recently introduced an Allergy Alert® app for Ford SYNC AppLink™ that allows drivers to check current and upcoming pollen and other health-risk conditions with simple voice commands while keeping their hands on the wheel and eyes on the road. This app came out of research Ford began in 2012 to assess in-car health and wellness-connected services that could work with SYNC, such as medical device connectivity, cloud-based health management services and mobile app integration. As part of this research, we are also working with Microsoft, Healthrageous and BlueMetal Architects to develop additional systems that extend health management into the personal vehicle in a nonintrusive fashion.

We are also working on systems that can use Ford's hands-free SYNC communication technology to capture biometric and vehicle data as the basis for real-time health and wellness advice and monitoring. For example, a driver could provide voice inputs, detailing important aspects of his or her health routine – such as the number of glasses of water consumed during the day, or what pills have been taken. Working with partner companies, the data received from the driver can be uploaded into the driver's approved health data cloud and processed with other health data to create visual reports the driver can access after having left the vehicle.

As part of our efforts to deliver healthy vehicle interiors, we are also researching microbial populations on vehicle interior surfaces with the goal of creating a cleaner, more aesthetically pleasing environment for our customers. Microscopic organisms, including mold and mildew, can spread over a variety of surfaces, leading to discoloration and even unpleasant odors. We worked with a team from the University of Michigan to evaluate the concentration and growth of microbes in vehicles. After identifying the hot-spot locations for microbial growth, we are now developing and testing part-coating formulations that could resist and potentially even reverse microbial growth, including silver-ion, ammonium salt and polyolefin wax with a nano-silver coating. Parts with the antimicrobial-treated coating are now undergoing real-world testing in a number of Ford development vehicles, and the coating is being evaluated for potential use in future Ford vehicle programs.

Eliminating Undesirable Materials

For more than 20 years, our Restricted Substance Management Standard has spelled out materials to be avoided or eliminated in Ford operations, and in the parts and materials provided by suppliers. This and other materials-management tools are helping us to meet and exceed customer expectations and ensure compliance with regulations.

Related links

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Eliminating Mercury, Chromium and Lead

Ford has eliminated the use of mercury-containing components, which can pose problems at the end of a vehicle's life. In 2001, we eliminated mercury-containing switches, which accounted for more than 99 percent of the mercury used in our U.S. vehicles. Since that time, we have continued to focus on mercury reduction, eliminating mercury in navigation system screens and family entertainment system screens, and reducing the use of mercury in high-intensity discharge headlamps. All Ford and Lincoln vehicles in all of our operating regions are now mercury free.

In addition, we helped to forge a collaboration between the U.S. Environmental Protection Agency (EPA), states, auto dismantlers, auto-scrap recyclers, steelmakers and environmental groups to recycle mercury switches from end-of-life vehicles. This effort was rolled out across the U.S. in 2007 and now has more than 9,400 participants joining the effort from the recycling industry. By the end of 2013, more than 6 tons of mercury from these switches had been recovered. An online database tracks the number of participants in the program as well as the number of switches collected by each state.

In Europe, an EU End-of-Life Vehicle Directive and a Battery Directive prohibit the use of the heavy metals lead, cadmium, hexavalent chromium and mercury, with limited exceptions. These regulations also include broad manufacturer responsibility for disposing of vehicle parts and substances, including taking vehicles back without charge for disposal and recycling requirements. This legislation has triggered similar regulatory actions around the globe, including, for example, in China and Korea and possibly in India in the near future. Ford is complying with all of these regulations.

Hexavalent chromium – "hex chrome" for short – is a corrosion coating (used, for example, on nuts, bolts and brackets in cars and trucks) that the U.S. Occupational Safety and Health Administration lists as a potential lung carcinogen. We did not wait for global regulations banning the use of hex chrome to take effect: We phased out its use worldwide. By 2007, Ford eliminated all hex-chrome-containing parts in Europe and North America. Replacement coatings have been thoroughly tested to ensure that they meet Ford's performance requirements.

In North America, Ford has also completed the transition away from lead wheel weights. In addition, Ford's Customer Service Division no longer offers lead wheel weights for sale to dealers, offering steel wheel weights instead.

Ford has joined the U.S. Environmental Protection Agency and other stakeholders in a commitment to reduce the use of lead in wheel weights through participation in the National Lead-Free Wheel Weight Initiative. Through this initiative, Ford has shared its experience with lead wheel weight phase-out with aftermarket wheel balancers, and encourages all stakeholders to discontinue the use of lead in wheel weights.

In mid-2003, Ford of Europe phased out lead in valve seats in all new vehicle models approved for launch in the European Union. Also in Europe, we phased out the use of lead wheel weights and reduced the lead content in aluminum in new and serviced vehicles in mid-2005, and phased out lead in pyrotechnic initiators by mid-2006. We further reduced the lead content in aluminum in 2008. A study by the Oeko Institute in Germany calculated that, between 2000 and 2005, life cycle emissions from lead had been reduced by 99.6 percent, from hexavalent chromium by 99.99 percent and from cadmium by 96 percent in Europe.

Reducing Undesirable Chemicals

Ford is one of the first automotive companies to begin efforts to reduce a range of undesirable chemicals that are monitored by the EU, U.S. and Canadian governments. These chemicals include hexabromocyclododecane (HBCDD), a chemical that has been identified as a substance of concern under the European Union's REACH regulations (Registration, Evaluation, Authorization and restriction of CHemicals). Ford is also working to reduce decabromodiphenyl ether (decaBDE), another substance of concern that the U.S. EPA and Canadian EPA have proposed to regulate. Ford is working to eliminate these substances ahead of the timelines defined by governmental regulations by working with suppliers to develop new and "greener" alternative materials that will make our products more environmentally friendly. Ford is also leading industry efforts to eliminate undesirable substances by chairing several industrial association working groups on this topic including the U.S. Council for Automotive Research Substances of Concern Committee and the Automotive Industry Action Group Chemical Management and Reporting Group. We are also collaborating with global automotive manufacturers and suppliers to develop strategies and plans to eliminate undesirable chemicals across the automotive industry.

More and more countries are adopting chemical and substance-of-concern regulations like REACH. Turkey and Romania adopted their own versions of REACH in 2009; China adopted its own version in October 2010. In 2011, Japan adopted REACH-like regulations to manage their chemicals. South Korea adopted REACH regulations in 2013 and will begin implementation in 2015. In the U.S., proposed legislation to overhaul the Toxic Substances Control Act is currently under consideration in Congress. The state of California finalized a Safer Consumer Products law, which took effect in 2013. And in January 2009, the United Nations implemented regulations requiring a globally harmonized system of classification and labeling of chemicals.

Regulatory requirements for the phase-out of undesirable chemicals need to be prioritized and implemented in a workable manner. Government and industry resource constraints mean that not all chemicals of concern can be addressed at once. Moreover, manufacturers and suppliers need adequate lead time to identify replacement substances that are more environmentally friendly than the ones they replace, and also to design and engineer components that incorporate these new substances. Ford will continue to work with regulatory agencies to help develop rules that target the highest-priority chemicals first, and that drive steady progress toward the elimination of chemicals of concern in an effective and efficient manner.

For more on Ford's efforts to manage materials and chemicals, please see the Materials Management section.

End of Life

Automobiles are one of the most highly recycled consumer products in the world. All vehicles contain parts and materials – particularly iron, steel and aluminum – that can be recovered at the end of their useful lives. In North America, about 95 percent of vehicles that go out of registration are processed by a dismantler or scrap metal recycling facility, with approximately 86 percent of the vehicle by weight recovered for reuse, remanufacturing or recycling.

In theory, end-of-life vehicles are more than 95 percent recoverable. In practice, however, the cost in energy and labor to recover the final fractions often exceeds the value of the materials, and recent independently reviewed environmental studies suggest that such efforts offer no value to the environment. Ford focuses on achieving the highest economically viable and environmentally sound recovery percentage through a number of means, including selection of materials, labeling and providing information to dismantlers on materials and methods for treatment.

In the EU, automakers are required by EU Directive 2000/53/EC to ensure a cost-free take-back of vehicles (that they put on the market) at the end of their lives. This directive also requires that end-of-life vehicles (ELVs) are treated in an environmentally responsible manner. Since 2002, Ford has been at the forefront of providing return networks in the EU member states that have established regulations. Ford now has ELV take-back and recycling networks for Ford brand vehicles in 19 EU markets and participates in collective ELV recycling systems in another 10. Ford was the first major manufacturer in the U.K. to put in place a comprehensive plan that met the European Commission's ELV Directive. By working with Cartakeback.com, Ltd., we have a network of nearly 230 facilities providing unrivaled convenience to the last owner for the professional take-back, receipt and treatment of end-of-life vehicles.

In May 2007, Ford became one of the first European automakers to be certified in compliance with ELV requirements by demonstrating to external authorities that the Ford processes properly manage the reusability, recyclability and recoverability aspects of vehicles. In 2014, this certification was extended by another two years and now comprises all of Ford Motor Company operations globally. All Ford vehicles marketed in Europe are now certified as reaching recyclability of 85 percent and recoverability of 95 percent. An increasing number of vehicle models produced and designed in the U.S. are also following this approach. For example, all U.S. models exported to South Korea are providing self-certification documents meeting the 85 percent to 95 percent recoverability requirement.

Ford has participated in research into alternative treatments for end-of-life vehicles. Most of the plastic, foam and other nonmetal vehicle materials end up being shredded. Most of this "automotive shredder residue" (ASR) ends up going to landfill. We have been working to assess the environmental impacts of burning ASR for energy. Together with other European automotive manufacturers, we sponsored a fully ISO 14040-compliant life cycle assessment that showed that – from a purely environmental point of view – using recycled ASR for energy recovery is as beneficial as recycling it.

Related links

External Websites

→ European End of Life Vehicles

Electrification: A Closer Look

Consumer interest in and demand for electrified vehicles (EVs) – which include hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs) and pure battery electric vehicles (BEVs) – have been growing. And recently, the rate of growth has increased significantly.

From 2000 to 2011 (i.e., the first 11 years that HEVs were available from major automakers in the U.S.), sales of EVs grew to just 2 percent of the total U.S. passenger vehicle market. But in 2012 and 2013, the market for EVs doubled; it now totals approximately 4 percent of U.S. passenger vehicle sales.

To meet this growing demand, most major automakers now offer some form of electrified vehicle. Ford offers six models, including three HEVs, two PHEVs and one BEV, as part of our "power of choice" strategy for delivering leading fuel economy for consumers regardless of what type of vehicle or powertrain technology they prefer. Sales of Ford's EVs grew substantially in the past year. In 2013, Ford sold nearly 88,000 EVs, a record number for Ford. Also in 2013, Ford's share of the overall EV retail market was 14.3 percent, up from 6.5 percent in 2012. Ford's EVs are also making a significant contribution to reducing carbon emissions. As of late April 2014, owners of Ford's plug-in electric vehicles, including the Focus BEV and Fusion and C MAX Energi PHEVs, had driven approximately 114 million all-electric miles, resulting in an approximately 8 million kg reduction in carbon dioxide (CO_2) compared to gasoline-powered miles[1].

Utilities are also working to understand how to provide power to plug-in vehicles in a way that is more effective in meeting consumer needs, more efficient for electricity providers and more environmentally sound. And a variety of organizations are developing infrastructure for charging vehicles at homes, at work and in other public places.

Why the rise in interest and activity in EVs? As gas prices remain high, consumers are increasingly interested in alternative and less-expensive fueling options, such as electricity. In addition, the cost of EVs continues to come down, due in part to technology advances and increasing production volumes. Other benefits of EVs can include lower greenhouse gas (GHG) emissions during vehicle use, increased use of domestic energy sources, decreased pressure on petroleum stocks and reduced urban air pollution. With the advanced information technologies and "smart grids," electrified automobiles can even improve the efficiency of the power grid – thereby lowering electricity costs – and facilitate the use of renewable energy sources, such as wind and solar.

Still, many challenges remain. For example, even though the purchase prices of EVs (especially HEVs) are beginning to become more competitive, the price premium over conventional vehicles remains significant. In addition, consumers continue to have concerns about the driving range of BEVs. And for EVs to achieve their full potential to cut lifecycle automotive GHG emissions, low-carbon electricity generation must make up a greater part of the total energy supply, and electric vehicles must become functioning parts of smart grids. Also, battery technologies are still evolving, and the cost of new-generation batteries remains high. We are also assessing supply-chain issues associated with the materials needed to manufacture batteries, including the availability of lithium and rare earth elements. Furthermore, customer demand for EVs must continue to grow for these vehicles to have a significant effect on overall transportation-sector emissions.

We discuss all of these issues in more detail throughout this section, which provides an overview of Ford's electrification strategy. The section also compares different electrification technologies and their environmental benefits. For more detail on Ford's electric-vehicle technologies and other fuel-efficiency, advanced powertrain and alternative-fuel technologies, please see the Sustainable Technologies and Alternative Fuels Plan.

LIVING THE ELECTRIC LIFESTYLE

To help drivers make the transition to electric vehicles (EVs), and get the most out of their EVs, we are offering more than just the vehicle. We are delivering a total electric vehicle lifestyle.

1. This CO_2 reduction value is a “net” well to wheels value based on the reduction in CO_2 emissions resulting from the greater efficiency of the electric versus the gasoline engine. But it also accounts for the fact that the grid electricity that is being used to recharge the vehicles also produces upstream CO_2 emissions. All-electric miles driven are calculated from data collected through the MyFord Mobile database.

Ford's Electrification Strategy

Ford foresees a future that includes different types of electrified vehicles (EVs), depending on customers' needs. There will not be a one-size-fits-all approach, but a diverse and smart range of applications of different types of electrified vehicle technologies. Our strategy includes the following elements.

Related links

Ford Websites

→ Plug into Ford

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"Power of Choice": Bringing a Range of Electrified Vehicles to Market

EVs are an important part of Ford's overall sustainability strategy and delivering on our commitment to reduce the carbon dioxide (CO_2) emissions of our fleet. We are pursuing an aggressive electrified-vehicle strategy that we call "power of choice." We believe that offering a range of electrified vehicles is the best way to reduce CO_2 emissions, deliver leading fuel economy across our lineup and meet different customers' transportation needs.

To do this, we are electrifying global vehicle lines rather than limiting development to a single, special electrified vehicle model. This allows our customers to choose from a variety of electrified vehicle powertrains – including hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs) and full battery electric vehicles (BEVs) – in a range of vehicle segments, including sedans, utility vehicles and luxury vehicles.

Ford Fusion Hybrid, Lincoln MKZ Hybrid, and Ford C MAX Hybrid

In the U.S., we offer three HEVs: the Ford Fusion Hybrid, the Lincoln MKZ Hybrid and the new C MAX Hybrid. In 2014, we plan to introduce a hybrid version of Ford Mondeo in Europe. These HEVs are ideal for customers who cover a range of distances in varied driving conditions. The most significant benefits come under urban stop-and-go driving conditions, in which braking energy is stored and reused. But these HEVs should also appeal to drivers who do a mix of city and highway driving. For more information about our hybrid vehicles and technology, please see the Hybrid Electric Vehicles section.

Ford Focus Electric

In 2012, we launched the Focus Electric, a BEV version of the new Ford Focus, to retail customers in North America. We introduced this vehicle in Europe in 2013. By using innovative technologies, the Focus Electric can be fully charged in under four hours. The Focus Electric has an EPA-certified driving range of 76 miles on a single charge and can go up to 100 miles on a charge depending on driving habits. (The average driver in the U.S. drives approximately 45 miles a day, according to the Bureau of Transportation Statistics.) For more information about our battery electric vehicles and technology, please see the Battery Electric Vehicles section.

Ford C MAX Energi and Ford Fusion Energi

In North America, we also sell two PHEVs: the C MAX Energi, launched in 2012, and the Fusion Energi, a plug-in hybrid version of our all-new Fusion that launched in early 2013. For more information about our PHEVs and technology, please see the Plug-In Hybrid Electric Vehicles section.

All of our electrified vehicles use state-of-the-art lithium-ion batteries, as discussed in the Battery Technologies section.

Sales of our electrified vehicles are increasing, and Ford is the second-leading seller of electrified vehicles in the U.S. For calendar year 2013, we held 14.3 percent market share in the U.S. EV market, up from approximately 6.5 percent in 2012. In 2013 we sold 87,776 total EVs – a record number for Ford. EVs accounted for 3.5 percent of total company sales, up from 1.6 percent in 2012.

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Using Global Platforms

We are basing our EV products on our highest-volume global platforms. This approach offers tremendous opportunities for production economies of scale. For example, the Focus Electric, C MAX Energi and C MAX Hybrid are based on Ford's next-generation compact, or "C-car" platform, and are being built alongside gas-powered Focus models at Ford's Michigan Assembly Plant. This plant is the first in the world to build vehicles with five different fuel-efficient powertrain technologies on the same line.

Globally, we expect to build as many as 2 million vehicles per year on the C-car platform. The new Fusion Hybrid and the Fusion Energi PHEV are based on our global mid-sized platform. This flexibility allows us to switch production between different vehicles as needed to meet changing consumer demand. We also share many of the electrified components between the different vehicles. These strategies are key to making electrified vehicles affordable.

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Delivering a Complete Electrified-Vehicle Lifestyle

EVs have many advantages for consumers. But they may sometimes require owners to adjust their travel routines and driving habits, and may cause some new considerations to arise in regard to how a driver uses a car. For example, BEV drivers have to plan for their car to have enough charge to get to the next destination. BEV and PHEV drivers have to consider where they will charge their vehicles. Even

HEV drivers can make changes to their driving routines to maximize the efficiency of their vehicles. To help drivers make the transition to EVs and get the most out of their EVs, we are offering more than just the vehicle. We are delivering a total electrified-vehicle lifestyle.

In the U.S., our electrified vehicles have advanced in-vehicle communications and innovative applications for wireless devices that help drivers maximize the efficiency and range of their vehicles. Our tools for BEVs and PHEVs also help drivers to find charging stations along their planned routes, and advise how far they can go until the next charge based on their own driving style. For example, our MyFord Mobile™ app, developed using MapQuest® and PlugShare technology, allows owners to control charging and other in-vehicle operations remotely. The app can "wake up" to preheat or precool the cabin while the car is plugged in, to help reduce battery usage for these energy-intensive functions. Owners can use MapQuest to find their way to a new destination and PlugShare to find public recharging stations. We have also developed a comprehensive approach to vehicle charging that makes it fast, easy, affordable and environmentally responsible. Our goal is to deliver EVs that are as engaging, easy to use and empowering as other forms of consumer electronics like smartphones.

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Improving the Electric Vehicle "Ecosystem"

The development and diffusion of EV technologies is a global challenge. It will take a collaborative approach of automakers, battery producers, suppliers, fuel producers, utilities, municipalities, educators and researchers, as well as policy makers, opinion shapers and consumers, to help us make the transition and realize the full benefits of electrification. We are collaborating with all of these players to develop an "electric vehicle ecosystem" that supports and enhances the operation of EVs and increases their benefits to customers and the environment.

Ford's plan calls for strategic partnering with key suppliers who bring technical expertise, financial solidity and collaborative spirit. We believe that working with a range of partners will allow us to gain greater understanding of the connectivity of vehicles to the electric grid, promote the necessary infrastructure and bring down the costs of the technology to make it more accessible for consumers. We are partnering with companies that are already the best in their fields, instead of attempting to recreate products, services and technologies internally, to offer customers the best possible suite of electrified vehicle-related products, services and technologies. For example, we are working with municipalities across the U.S. to help them develop infrastructure to support EVs including public charging stations. And, we are working with a coalition of other automotive manufacturers and other stakeholders to develop technologies, standards and cost efficiencies to commercialize EVs.

In January 2013, Ford launched the MyEnergi Lifestyle project, a collaboration with representatives of the consumer-appliance, renewable-energy and power-management industries to demonstrate how plug-in vehicle technology can be applied across household appliances and renewable energy generation for an energy- and money-saving lifestyle. Current partners include Whirpool, Easton, SunPower and Georgia Institute of Technology. Please see the longer "Improving the Electric Vehicle Ecosystem" for more information on our efforts in this area.

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Bringing EVs to Market Thoughtfully

Ford is taking a proactive approach to making PHEVs and BEVs successful in the marketplace including efforts to help customers and dealers better understand the technology. For instance, we have developed extensive training materials to educate dealers' sales personnel on the unique features and functionality of electric vehicles so that they are able to assist customers with their purchase decisions. As part of these preparations, dealers who sell BEVs and PHEVs are required to install two EV charge stations at their facilities – one in the service area and another in the customer-facing area. These dealers are also participating in a "green dealer on-site facility assessment" to identify energy- and cost-saving opportunities, with a goal to improve energy efficiency, lower operating expenses and reduce the dealership's carbon footprint. For more information on our "Go Green" dealer initiative, please see the Dealers section.

We have also developed websites, videos and brochures to help consumers understand our EV offerings and incorporate BEVs and PHEVs into their lifestyle. For example, our "green vehicles" website helps consumers understand the key features of and differences between electrified vehicle options, and our www.plugintoford.com site helps customers understand how to get the most from their electric vehicle. We have also developed videos on vehicle features such as MyFord Mobile, how to charge the vehicle or set the charge time, and how to have a charging station installed.

As part of our collaboration with dealers, utilities and local governments, Ford is helping to develop consumer outreach and education programs as well as share information on charging needs and requirements to ensure that the electrical grid can support customers' needs. For example, we launched a "Go Further" test drive tour in 17 U.S. markets as part of this effort. This tour promotes Ford's electric-vehicle strategy, solidifies our collaborations with local utilities and municipalities to make BEVs and PHEVs a success, and educates consumers about what to expect from electrified automobiles and what is needed from the public and private sector to support this new technology, all while giving them the opportunity to test-drive a Ford vehicle with fuel-efficient technology. In 2013, we also held consumer education events in key BEV and PHEV markets around the country; some were stand-alone Ford events and some were larger sustainable-lifestyle events in which we participated. These consumer education events included educational exhibits about Ford's electrified-vehicle offerings, the benefits of BEVs and PHEVs, and recharging options, as well as live demonstrations of the MyFord Mobile technology and the opportunity to test-drive Ford vehicles.

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Comparing Electrification Technologies

Electrified vehicle (EV) technologies range from conventional gas-engine vehicles with a start-stop function (sometimes referred to as micro hybrids), to hybrid electric vehicles (HEVs), plug-in electric vehicles (PHEVs), and battery electric (or "all-electric") vehicles (BEVs).These technologies offer a range of benefits that can vary with driving conditions. We believe it is important to offer customers a range of fuel-efficient and reduced-emission vehicles, including efficient traditional gas-powered vehicles and electrified vehicle options. We are also committed to helping customers understand the relative advantages of different vehicle options based on their driving needs. We call this approach the "power of choice."

In a recent national survey, we found that nearly half of Americans are confused about green vehicle options, with 46 percent not knowing the difference between a hybrid, plug-in hybrid and all-electric vehicle. This Sustainability Report is one of the key mechanisms we use to inform customers about the different electrified vehicle options. Ford also has a website explaining different fuel-efficient and alternative powertrain vehicles including EVs to help consumers understand the key features of and differences between electrified vehicle options. And, we explain the range of interactive tools available to drivers of our electrified vehicles on our www.plugintoford.com website. We are also reinforcing our power-of-choice product offerings through a "Go Further" tour that helps consumers learn more about electrified vehicles in an engaging, interactive atmosphere. Through all of these communication channels, we seek to help customers decide what vehicle technology is best for them.

The table below provides a generalized overview of the relative benefits and impacts of these different electrified vehicle technologies, based on typical compact C-class vehicles similar to those Ford currently offers (e.g., the Ford Focus, C MAX Hybrid, C MAX Energi and Focus Electric). Because no single Ford model is available with all of these alternative propulsion concepts, these values are approximate for comparison purposes only and do not reflect values for actual products.

	Conventional Internal Combustion Engine Vehicle (ICEV)	Conventional ICEV with Stop-Start Technology[1]	Hybrid Electric Vehicle (HEV)	Plug-In Hybrid Electric Vehicle (PHEV)	Battery Electric Vehicle (BEV)
Technology overview	Traditional gas or diesel engine.	Traditional gas or diesel engine and powertrain with manual and automatic transmissions with stop-start capability, which shuts down the engine when the vehicle is stopped and automatically restarts it before the accelerator pedal is pressed to resume driving. Smart regenerative brake recharging improves fuel economy.	Uses both an internal combustion engine and an electric motor. Can run exclusively on battery power, exclusively on gas power or on a combination of both. Also has stop-start capability and regenerative braking.	Uses a high-capacity battery that can be charged from an ordinary household 120-volt (V) outlet or a 240V charging station. When the battery is depleted, the PHEV runs like a regular HEV.[2]	Uses only a battery-powered electric motor, no gas or diesel engine. Runs entirely on electricity from batteries, which can be charged from household outlets or specialized charging stations.
Ideal driving conditions	Flexible for a wide range of uses.	Flexible for a wide range of uses. Improved fuel economy in urban driving.	Flexible for a wide range of uses. Excellent urban fuel economy and improved highway fuel economy.	Flexible for a wide range of uses. Dramatically improved fuel economy. Suitable for customers who have access to a 120V outlet or 240V charging station at home and/or the office. Can provide	Ideal for customers with access to a charging station at home or work who have shorter, predictable daily trips of less than 80 miles (between charges).

				approximately 20 miles in pure electric mode, but is flexible for longer trips as well.	
Technology Benefits/Costs Based on a Typical Compact or "C-class" Sedan[3]					
Fuel economy[4]	˜31 mpg	˜32 mpg	˜40 mpg[5] combined city and highway	88 MPGe[6] (combined city and highway) in electric mode. ~38 MPG using gasoline in hybrid mode.	105 MPGe[7]
Range on tank/charge[8]	˜420 miles/tank	˜430 miles/tank	˜580 miles/tank	˜550 miles on combined gas and electric power. More than 1,000 miles between visits to a gas station in typical use.	Up to 76 miles on a charge
Fueling/charging time	Minutes	Minutes	Minutes	Minutes for gasoline; 2.5 hours with a 240V outlet and 7 hours with a 120V outlet.	Up to four hours with a 240V outlet if equipped with a 6.6 kW charge port
CO_2 emissions[9]					
Well to tank[10]	˜50 g/km	˜50 g/km	˜40 g/km	˜40 g/km	n/a
Tank to wheels[11]	˜165 g/km	˜160 g/km	˜130 g/km	˜135 g/km	n/a
Electricity generation[12]	n/a	n/a	n/a	170 g/km	140 g/km
Total CO_2[13]	˜215g/km	˜210 g/km	˜170 g/km	˜175 g/km[14]	˜140 g/km
Annual fuel cost	˜$1,200–1,900[15]	˜$1,200–1,900[16]	˜$900–1,500[17]	˜$750–$1,050 ($500–$800 for gasoline + $250 for electricity)[18]	˜$450[19]

1. Some automakers consider this a form of hybrid vehicle. However, Ford views and is implementing these technologies as part of our strategy to improve the fuel economy of conventional internal-combustion engine vehicles. We assume start-stop technology can provide up to 6 percent fuel economy improvement in city driving.
2. Another type of PHEV, often called an Extended-Range Electric Vehicle, runs entirely on battery power until the battery is depleted, and then the onboard gas-powered engine runs to recharge the battery. The wheels are driven only by the electric motor, and the engine's sole purpose is to recharge the battery.
3. These numbers are for comparison purposes only. They are based on modeling and testing calculations and do not necessarily represent the numbers that would be achieved in real-world driving conditions, nor do they represent actual products that Ford currently makes or may produce.
4. The internal-combustion engine fuel-economy estimate is based on the calculation used by the U.S. Environmental Protection Agency to develop combined fuel-economy (city/highway) values for the labels affixed to new vehicles. The combined fuel-economy value is intended to represent the approximate fuel economy that most consumers can expect based on a typical mix of city and highway driving. Estimates for the other technologies are based on the metro-highway drive cycle used for the U.S. fuel-economy regulations. Fuel-economy calculations for all of the technologies are based in U.S. gallons and on U.S. drive cycles.
5. In general, HEVs deliver approximately 30–40 percent better fuel economy than comparably sized non-hybrids.
6. MPGe or miles per gallon equivalent for electric vehicles is calculated based on the 33.7 kWh energy content of a gallon of gasoline.
7. MPGe or miles per gallon equivalent for electric vehicles is calculated based on the 33.7 kWh energy content of a gallon of gasoline.
8. All estimates are based on a 13.5-gallon tank except for the BEV, which has no fuel tank.
9. In vehicles using internal combustion engines, the fuel feedstock is assumed to be E10, petroleum gasoline blended with 10% ethanol by volume.
10. Well-to-tank emissions represent the CO_2 generated by excavating feedstocks and producing and distributing the fuel.
11. Tank-to-wheels emissions represent the CO_2 generated by burning the fuel in the vehicle.
12. Electricity generation represents the CO_2 emitted by excavating feedstocks and generating and transmitting electricity, on average for the U.S. grid.
13. Total CO_2 is the sum of the well-to-tank, tank-to-wheels and electricity generation emissions. The PHEV total CO_2 emissions are weighted by the share of miles traveled in electric and gasoline modes.
14. Total CO_2 for the PHEV assumes an all-electric range of 20 miles and a utility factor of 48 percent (SAE J2841). The utility factor indicates the percentage of distance the vehicle is driven using electricity.
15. Based on 12,000 miles/year, 31 mpg and $3–5/gallon.
16. Based on 12,000 miles/year, 32 mpg and $3–5/gallon.
17. Based on 12,000 miles/year, 40 mpg and $3–5/gallon.
18. Based on 12,000 miles/year, 48 percent in electric mode at 2.7 miles/kWh (EPA 37 kWh/100 miles, combined) and 12 cents/kWh, and 52 percent in gasoline-engine mode at 38 mpg and $3–5/gallon.
19. Based on 12,000 miles/year, 3.1 miles/kWh (EPA 32 kWh/100 miles, combined) and 12 cents/kWh.

Climate Change and the Environment

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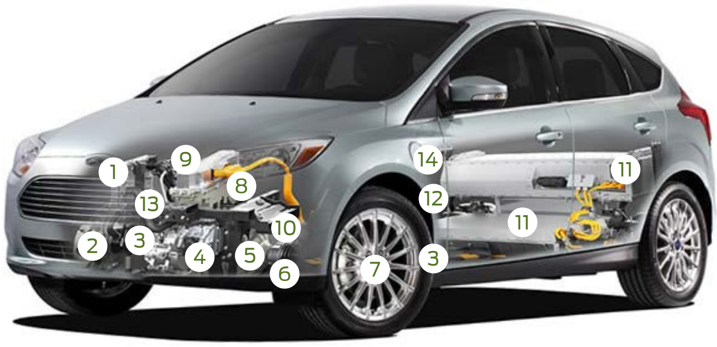
BEV Technology Overview

Below is a detailed look at the components that are used in the Ford Focus Electric, our battery electric vehicle (BEV).

Ford Battery Electric Vehicle

1. Motor Controller and Inverter
2. High-Voltage Electric HVAC Compressor
3. Electric Water Pump
4. Traction Motor
5. Electric Power Steering
6. Transmission
7. Regenerative Braking
8. Electric Vacuum Pump
9. High-Voltage Electric Coolant Heater and Controller
10. Powertrain Control Module
11. Battery Pack
12. AC Charger
13. DC-DC Converter
14. Charge Port Light Ring



1 Motor Controller and Inverter

The motor controller monitors the motor's position, speed, power consumption and temperature. Using this information and the throttle command from the driver, the motor controller and inverter convert the DC voltage supplied by the battery to three precisely timed signals used to drive the motor.

2 High-Voltage Electric HVAC Compressor

The high-voltage air-conditioning system is specifically designed for electric-vehicle applications, drawing electrical energy directly from the main battery pack.

3 Electric Water Pump

The electric-drive water pump circulates coolant for the traction motor, inverters, battery and climate-control system.

4 Traction Motor

The traction motor performs the conversion between electrical and mechanical power. Electric motors have efficiencies three times higher than that of a standard gasoline engine, minimizing energy loss and heat generation.

5 Electric Power Steering

An electro-hydraulic steering pump was installed to assist a retuned steering rack. It is tuned to deliver the same driving dynamics as the gasoline-powered Focus.

6 Transmission

The transmission has the identical role as in a conventional gasoline-powered vehicle; however, it has different design considerations due to the higher RPM range available from the electric motor and the increased emphasis on efficient and silent operation. The transmission is a single-speed unit.

7 Regenerative Braking

More than 95 percent of the energy normally lost through braking can be recovered and stored in the battery.

8 Electric Vacuum Pump

The vacuum pump provides energy-efficient power-assisted braking.

9 High-Voltage Electric Coolant Heater and Controller

Heating systems are specifically designed for electric vehicle applications using energy-efficient technology to heat the coolant that circulates to the passenger car heater. Heat also may be circulated to the battery to optimize performance.

10 Powertrain Control Module

The powertrain control module monitors and controls each vehicle system, and manages the energy and mechanical power being delivered to the wheels to maximize range.

11 Battery Pack

The battery pack is made up of 86 cells for a total of 23 kWh of power. The batteries are liquid cooled. The pack includes an electronic monitoring system that manages the temperature and state of charge of each of the cells.

12 AC Charger

Power electronics are used to convert the off-vehicle AC source from the electrical grid to the DC voltage required by the battery, thus charging the battery to its full state of charge in a matter of hours. The current charger is air cooled. The production design will accommodate both 110 and 220 voltage sources.

13 DC-DC Converter

A DC-DC converter allows the vehicle’s main battery pack to charge the on-board 12V battery, which powers the vehicle’s various accessories, headlights and so forth.

14 Charge Port Light Ring

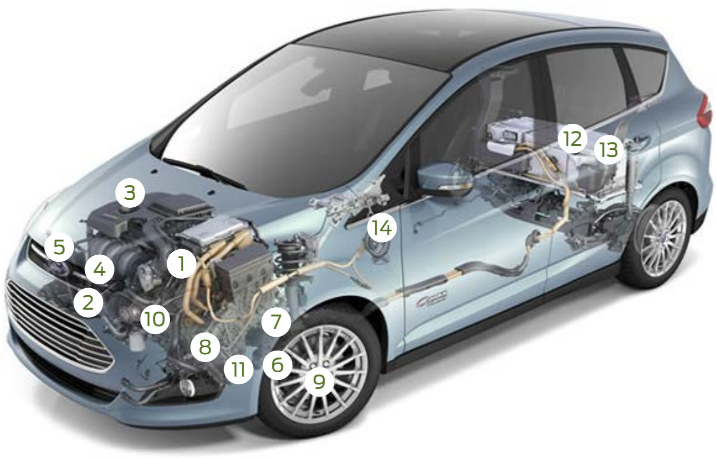
A standard SAE J1772 plug interface is used for charging. Ford’s charge port “light ring” provides an external indicator of charging status.

PHEV Technology Overview

Below is a detailed look at the components that are used in the Ford C MAX Energi, one of our plug-in electric vehicles (PHEV).

Ford C MAX Energi Plug-In Hybrid

1. Inverter System Controller
2. Air Conditioning Compressor
3. 2.0L Atkinson-Cycle Gasoline Engine
4. Electric Water Pumps
5. Electric Heater
6. Electric Power Steering
7. Hybrid Transmission
8. Transaxle Oil Pump
9. Regenerative Braking
10. Electric Vacuum Pump
11. Engine Control Module
12. Advanced Lithium-Ion Battery Pack
13. Onboard Charger Module
14. Charge Port Light Ring



1 Inverter System Controller

The inverter system controller manages hybrid powertrain control, including DC-to-AC conversion, driving the electric motors in the transmission for optimal fuel economy while providing the performance drivers want.

2 Air Conditioning Compressor

Specifically designed for electrified-vehicle application, the compressor draws energy directly from the high-voltage battery pack, which allows the engine to turn off more frequently to save fuel while enabling cabin cooling to continue.

3 2.0L Atkinson-Cycle Gasoline Engine

This all-new, high-efficiency, advanced four-cylinder engine has independent variable camshaft timing and delivers fuel efficiency and performance.

4 Electric Water Pumps

The main electric water pump provides engine cooling. Smaller pumps provide inverter system controller cooling and heater core coolant circulation when the engine is off.

5 Electric Heater

The electric heater is an energy-efficient technology that heats coolant; it is specifically designed for use on electrified vehicles.

6 Electric Power Steering

The electric power steering is tuned to deliver class-leading steering feel. It also is available with the Active Park Assist feature.

7 Hybrid Transmission

The PHEV's hybrid transmission includes an electric traction motor capable of providing 88 kW of power, coupled with a generator in a powersplit transaxle. It provides an electronically controlled, continuously variable transmission function, which harmoniously manages power from the gasoline engine.

8 Transaxle Oil Pump

The oil pump provides powersplit transaxle cooling, which is required by increased electric-only driving.

9 Regenerative Braking

With the regenerative-braking technology, more than 95 percent of the energy normally lost through braking is recovered and stored in the battery via the electric drive.

10 Electric Vacuum Pump

The electric vacuum pump provides energy-efficient, power-assisted braking.

11 Engine Control Module

The engine control module manages engine control systems to maximize fuel economy and minimize emissions.

12 Advanced Lithium-Ion Battery Pack

The advanced lithium-ion battery pack provides total energy of 7.6 kWh with air cooling for thermal management. It also includes a control module that manages temperature and state of charge, and a DC-to-DC converter that provides 12V battery to power vehicle accessories (headlights, etc.).

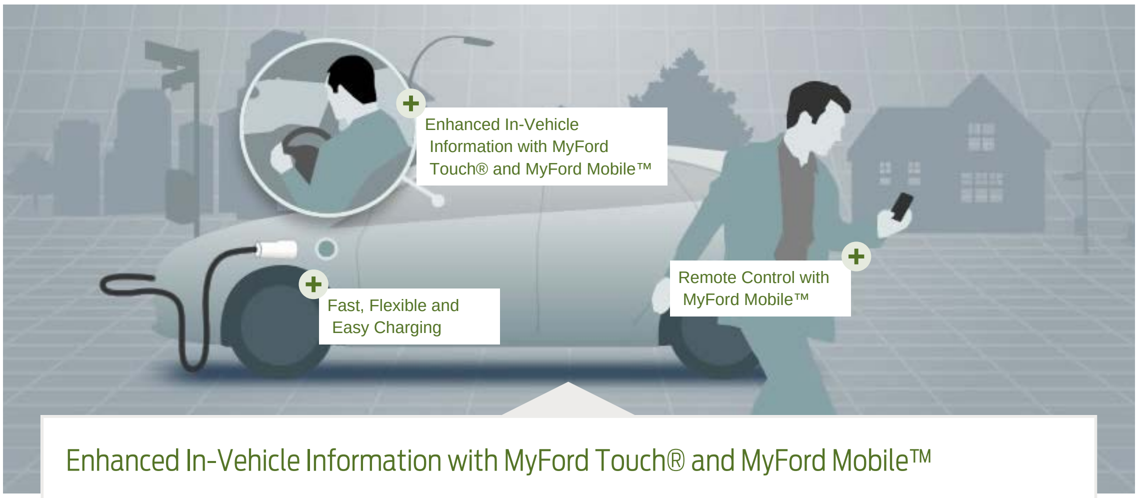
13 Onboard Charger Module

Packaged in the battery pack, an onboard charger module converts AC utility power to DC battery storage energy.

14 Charge Port Light Ring

A standard SAE J1772 plug interface is used for charging. Ford's charge port "light ring" provides an external indicator of charging status.

Living the Electric Lifestyle



Enhanced In-Vehicle Information with MyFord Touch® and MyFord Mobile™

Remaining distance calculation

The MyFord Touch® system is customizable; it shows the distance to the next required charge point, among other options.

Remaining charge calculation

The Focus Electric will continuously analyze a driver's style, recalculate range and distance to required charge, and show how driving behavior affects the vehicle's energy "budget."

Efficiency coach

The Focus Electric will continuously analyze a driver's style and show how driving behavior affects the vehicle's energy "budget." The system can also coach drivers on how to drive more efficiently to maximize their electric driving range.

View power demands of vehicle accessories

The MyFord Touch system will provide vehicle data, such as the electrical demands of vehicle accessories – including air conditioning, which influences the electric driving range.

Fast, Flexible and Easy Charging

Charging status display lights around port

We are making charging easier with an easy-to-read light ring around the charge port. When the plug is connected, the light loops around the port twice. The light ring then illuminates in quadrants as the vehicle charges.

Completely recharge at home in just four hours

The Focus Electric uses a 6.6 kW charger, which enables an at-home charge time of four hours when using a 240V charge station installed in the customer's garage. Ford branded Level 2 chargers, available from AeroVironment or Leviton, charge the vehicle more quickly than Level 1 stations, they allow drivers to plan vehicle charging to take advantage of lower "time-of-use" rates and they allow drivers to "precondition" the internal temperature of their vehicles while still plugged into the station.

Smart charge schedule charges during off-peak rates

U.S. drivers can customize charging preferences and times based on when utility rates are lowest in their area. Customers reduce their electricity costs by taking advantage of off-peak or other reduced utility rates without a complicated set-up process.

Remote Control with MyFord Mobile™

Remote locking and unlocking

Like any Ford vehicle equipped with MyFord Touch®, our electric vehicles allow drivers to remotely start the vehicle and remotely lock and unlock the car doors using their smartphone.

Monitor your charge and receive alerts

Drivers can monitor the car's state of charge and current range, get alerts when it requires charging, remotely program charge settings and download vehicle data for analysis from their smartphone or a secure Ford website.

Find charge stations

Working with MapQuest®, MyFord Mobile can communicate the location of a charge station to the Focus Electric using SYNC®'s Traffic, Directions and Information.

Locate your vehicle

Like any Ford vehicle equipped with MyFord Touch, our electric vehicles allow drivers to locate the vehicle with GPS.

Compare driving efficiency with friends

MyFord Mobile for EVs also adds a social element. Drivers can compare their driving efficiency to friends and other EV drivers.

To help drivers make the transition to electric vehicles (EVs), and get the most out of their EVs, we are offering more than just the vehicle. We are delivering a total electric vehicle lifestyle. In the U.S., for example, our EVs have advanced in-vehicle communications that help drivers maximize the efficiency and range of their vehicles, find charging stations along their planned routes, and know how far they can go until the next charge based on their own driving style. We have also enabled drivers to connect their smartphones to our vehicles so that they can control charging and other in-vehicle operations remotely. And, we have developed a comprehensive approach to vehicle charging that makes charging fast, easy, affordable and environmentally friendly. Our goal is to deliver electric vehicles that are as engaging, easy to use and empowering as other forms of consumer electronics like smartphones. Our "Plug Into Ford" website provides customers with an in-depth look at how to make the most of the electric-vehicle lifestyle.

Enhanced In-Vehicle Information through SYNC® with MyFord Touch® and SmartGauge® with EcoGuide

We designed our battery electric (BEVs) and plug-in hybrid vehicles (PHEVs) to provide more electric range at full charge than most Americans will use each day. But we know that for BEVs, at least initially, driving range between charges will be an important factor for consumers. So we have designed in-vehicle communications to make on-board energy management a rewarding and fun part of the ownership experience.

In the U.S. and Canada, our electric vehicles include an enhanced version of SYNC with MyFord Touch – Ford's driver interface technology – that includes next-generation SmartGauge with EcoGuide. SmartGauge with EcoGuide gives drivers real-time feedback on the efficiency of their driving habits and tips on driving more efficiently through vehicle displays. The system also helps drivers plan the most environmentally responsible route and manage the battery-charging process. For example, the system can provide vehicle data such as the electrical demands of vehicle accessories – including air conditioning, which influences the electric driving range. It also provides information on the battery's state of charge, distance to charge points, "energy budget" and expected range surplus.

The system even analyzes individual driving styles, as well as climate control and other options, to provide tailored information about range and remaining charge. Drivers who drive slowly and smoothly have a greater electric range compared with more aggressive drivers. The Focus Electric continuously analyzes a driver's style, recalculates range and distance to required charge, and shows how driving behavior affects the vehicle's energy budget. The vehicle recognizes drivers by their key fobs so that the data provided takes into account their unique driving style. The system can also coach drivers on how to drive more efficiently to maximize their electric driving range.

SYNC with MyFord Touch

SYNC with MyFord Touch with next-generation SmartGauge gives drivers real-time feedback on the efficiency of their driving habits and tips on driving more efficiently.

MyFord Mobile™ also helps drivers plan their trip based on the available battery range and the location of charging stations. The trip-planning system integrates information about driving style and the driving efficiency "coach" to help drivers go farther on their remaining charge by maximizing regenerative braking, turning down the air conditioning or other efficient driving actions.

The Focus Electric's in-vehicle information is also customizable. For example, information can be viewed in three different modes: Energy Budget, which shows the remaining charge; Range, which shows the distance to the next required charge point; and Surplus View, which shows drivers how much energy or range they are saving by using different options and driving efficiently. The system also uses a variety of simple graphics like an energy "budget cup" and surplus energy "butterflies" and "growing leaves" that make it easy for drivers to quickly interpret information.

Finally, on our Energi plug-in hybrid vehicles, SmartGauge also includes EV+, a program that learns drivers' frequent destinations and adjusts how the electric power stored in the vehicle's high-voltage battery is used to power the vehicle. If EV+ determines the vehicle is within a radius of 1/8 mile, or 200 meters, of a frequent stop, the vehicle has increased capability to stay in electric-only mode, the internal combustion engine stays off, and an "EV+" light appears on the dashboard, further reducing fuel use.

Remote Control with MyFord Mobile

Drivers in the U.S. and Canada can manage their Ford Focus Electric, C MAX Energi and Fusion Energi remotely using the Ford-developed MyFord Mobile app. This app allows drivers to locate the vehicle with GPS, remotely lock and unlock the car doors using their smartphone. On our electric vehicles, the MyFord Mobile app provides a suite of additional remote communications. Working with MapQuest® and PlugShare, for example, the MyFord Mobile app can find the location of a charge station on the driver's smartphone and send that location to the Focus Electric using the SYNC services. For the Focus Electric, C MAX Energi and Fusion Energi, the MyFord Mobile app uses PlugShare to provide users with the most comprehensive database of public charging stations in the U.S. and Canada. Drivers can also get instant vehicle status information, monitor the car's state of charge and current range, receive alerts when it requires charging, remotely program charge settings and review vehicle data for analysis – all using their smartphone or the MyFord Mobile website. Many of the vehicle's screens and control panels are integrated into the MyFord Mobile app's smartphone display, so that drivers can move seamlessly from their car to their phone displays.

MyFord Mobile app

The MyFord Mobile app provides a suite of remote communications features to help drivers manage their electric vehicles.

The MyFord Mobile app also allows drivers to program their vehicle to use electricity from the grid to heat or cool the battery and cabin while the vehicle is still plugged in. This "preconditioning" of the vehicle's temperature is a key strategy drivers can use to maximize their driving range.

The MyFord Mobile app for EVs also adds a social element by allowing drivers to compare their driving efficiency to that of friends and other EV drivers through seamless connections to popular social platforms like Facebook and Twitter. In addition, the system gives drivers virtual awards and badges for improvements in driving efficiency.

The remote vehicle monitoring and management features of MyFord Mobile were honored with the Best of Innovation Award at the 2012 International Consumer Electronics Show; they also won the 2013 IxDA (Interaction Design Association) Interaction Award for Optimizing category, which honors technologies that make daily activities more efficient.

For more information, see the MyFord Mobile features video demonstration.

Fast, Flexible and Easy Charging

Charging is one of the most important changes drivers have to get used to with a battery electric vehicle (BEV) or plug-in hybrid electric vehicle (PHEV). Customers typically choose from two common methods for charging their vehicles when at home. Level 1 charging uses a 110 volt (V) outlet, which is standard in most U.S. households or Level 2 charging, which sometimes requires installation of a new electrical circuit. All Ford plug-in vehicles come with a Level 1 charging cord, which fully charges a depleted C MAX Energi or Fusion Energi in seven to eight hours. This charging can usually be completed overnight, which can take advantage of lower electricity prices. The Level 2 chargers, which use 240 volt circuits, are another charging option, which can have significant advantages particularly for pure battery electric vehicles like the Focus Electric. Level 2 charging stations charge the vehicle more quickly than a Level 1 station, meaning a full charge takes less time and even quick convenience charging while running errands can increase electric miles driven. They also allow drivers to plan vehicle charging to take advantage of lower "time-of-use" rates. And, they allow drivers to "precondition" the internal temperature of their vehicles while still plugged into the station, rather than using the vehicle battery to cool or heat the vehicle while driving, which will reduce the vehicle's range. A survey commissioned by Ford in early 2014 shows that BEV[1] drivers are three times as likely to own Level 2 chargers compared to Level 1 chargers, while PHEV owners are more evenly divided between Level 1 and Level 2 chargers. We encourage PHEV and BEV drivers to install Level 2 chargers through our marketing materials, websites and dealer training as we believe the faster charging and other benefits will significantly influence customer satisfaction with plug-in vehicles.

We are working with AeroVironment and Leviton charge station providers to develop a Level 2 charging station program to help drivers maximize the benefits of their plug-in vehicles.

The Focus Electric is equipped with a 6.6 kW charger, which enables an at-home charge time of under four hours when using a 240V charge station installed in the customer's garage. The 6.6 kW charger also allows drivers to get more range out of "quick-stop" charging during the course of their driving day. The Focus Electric can get approximately 30 miles of range per "charge hour," while our C MAX Energi and Fusion Energi can get approximately 15 miles per charge hour with their 3.3 kW charge port.

In the U.S., Ford EV drivers can also customize their charging preferences. Drivers can choose the times when their car is ready to go and set a charging schedule that dictates when the charging starts and stops to meet those needs. They can also control vehicle charging using Value Charging, a system that sets up charging times based on when utility rates are lowest in their area. With Value Charging, customers can reduce their electricity costs by taking advantage of off-peak or other reduced utility rates without a complicated setup process. Customers can thus “set it and forget it,” knowing their vehicle will only charge when utility rates are at their lowest. And, our faster charge times make it easier to get a complete charge within the time periods of the lowest utility rates. Our system also sends vehicle owners reminders if their vehicle is not plugged in for a programmed charge time or if their vehicle is unplugged or stops charging unexpectedly during charging. To our knowledge, Ford is the only automaker with a nationwide database of time of use and electrical rates. Our customers gain access to this by participating in MyFord Mobile.

We are also making charging easier with an easy-to-read “light ring” around the charge port. When the plug is connected, the light loops around the port twice to acknowledge a proper connection between the vehicle and the charging station. The light ring then illuminates in quadrants as the vehicle charges, where each quadrant lit represents 25 percent of the battery’s state of charge. Flashing quadrants signify that the charge is in progress. When the ring is solidly lit, the vehicle is fully charged. Drivers can also find out their vehicle’s state of charge by pressing a button on their key fob; in response, the light ring indicates the amount of charge by lighting the appropriate number of segments of the “light ring.”

Similar to our “power of choice” approach to providing customers a range of fuel-efficient and advanced technology vehicle options, we also offer drivers a range of choices for charging their BEV or PHEV. In the U.S., our recently refined process gives drivers the choice of two charging station installation methods. Customers can opt to purchase the Ford-branded charging station from Leviton or AeroVironment and use an electrician of their choice. Or, customers can choose a full-installation option, in which installation services are provided by AeroVironment using an experienced national network of electricians who handle every aspect, from site survey to completed installation. With the full installation option, charging stations can be installed in one day, at a time and date selected by the customer.[2] The customer can use either a website or call center to schedule and track their purchase and installation. In Europe, we offer a similar service through a relationship with Schneider Electric. Electric vehicle buyers will be registered online at the dealership for a consultation to determine the appropriate installation based on their home electrical system.

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1. This includes drivers of mid-range BEVs with a range of 150 miles or less. It includes drivers of Ford and competitor BEVs.
2. Assumes standard installation in an attached garage. Installation times may vary depending on site conditions and local permitting requirements. Other restrictions may apply. Contact installer for complete details.

Maximizing the Environmental Benefits of Electrified Vehicles

Pure battery electric vehicles (BEVs) are considered "zero emission" because they don't release greenhouse gases or other pollutants during use. But that term can be confusing, because it takes electricity to charge the vehicle, and the power plant generating the electricity may also generate emissions. Electric vehicles do reduce pollutants generated by burning petroleum fuel in the vehicle, in proportion to the reduction in vehicle fuel consumption. However, replacing gasoline with electricity generated from coal, for example, results in emissions at the power plant, including carbon dioxide (CO_2), nitrogen oxides, sulfur dioxide, volatile organic compounds, carbon monoxide and particulate matter. As a result, the environmental benefits of BEVs and plug-in hybrid electric vehicles (PHEVs) depend largely on the fuels used to power the electrical grid. Operating a PHEV or BEV on the current average U.S. electrical grid, which relies heavily on coal power, results in well-to-wheel emissions that are similar to those of a hybrid electric vehicle (HEV), but the emissions of BEVs, PHEVs, and HEVs are significantly better than vehicles powered by a traditional internal combustion engine. (See the well-to-wheels CO_2 emissions values on the Comparing Electrification Technologies page.)

In some regions, however, where electrical power is derived largely from cleaner sources, the emissions benefits of PHEVs and BEVs can be much greater, because renewable energy sources produce significantly fewer emissions than coal and natural gas. We believe that, over time, the emissions benefits of PHEVs and BEVs will continue to improve as states undertake efforts to improve the emissions profiles of their electrical grids. Already, many states have portfolio standards that require the use of renewable sources of electricity. "Smart grids" that include grid-to-vehicle communications would enable utilities to make even more efficient use of electricity supplies, potentially reducing emissions and electricity costs. (See MyEnergi Lifestyle for an example of how connected technologies can improve the efficiency of vehicles, homes and electric power generation.)

There has been some discussion regarding whether the additional GHG burdens associated with manufacturing electric vehicles outweigh their benefits while in operation. The U.S. Department of Energy has conducted an investigation of the "cradle-to-grave" (C2G) emissions associated with electric vehicles[1]. The C2G analysis encompasses resource extraction (cradle), transformation of resources into fuels and vehicles, vehicle operation, and vehicle end-of-life disposal and recycling (grave). The U.S. Department of Energy assessment concluded that for today's plug-in vehicles, the battery cycle contribution to C2G GHG emissions is 1-8 percent and does not negate the environmental benefits of electrified vehicles.

We know that Ford EVs are already helping to reduce CO_2 emissions. As of late April 2014, Ford plug-in electric vehicles (the Focus Electric BEV and Fusion Energi and C MAX Energi PHEVs) had been driven for approximately 114 million electricity-powered miles. These "all-electric" miles have resulted in a reduction of approximately 8 million kg of CO_2[2] compared to gasoline powered driving. Approximately every three days, Ford PHEV and BEV owners drive another million "all-electric" miles.

In 2014, we revealed a solar-powered C MAX Energi PHEV concept vehicle. The solar C MAX Energi concept charges its battery by collecting solar power instead of plugging into an electrical outlet. It uses a special concentrator that works like a magnifying glass to direct intense rays to solar panels on the vehicle's roof. This rooftop solar system allows the C MAX Solar Energi Concept to charge its battery without using the traditional electric grid. However, the vehicle still has a charge port, and can be charged by connecting to a charging station via cord and plug so that drivers retain the option to power up using the traditional electrical grid, if desired. With a full charge, the Ford C MAX Solar Energi Concept is estimated to have the same total range as a conventional C MAX Energi of up to 550 miles, including up to 20 electric-only miles. Internal Ford data suggest the sun could power up to 75 percent of all trips made by an average driver in a solar hybrid vehicle. This could be especially important in places where the electric grid is underdeveloped, unreliable or expensive to use. The Ford C MAX Solar Energi Concept is estimated to reduce the annual greenhouse gas emissions a typical owner in the U.S. would produce by four metric tons by using renewable power, the amount an average U.S. household produces in four months. This vehicle won the "Best in Show" award at the 2014 Consumer Electronics Show.

To help customers think through the relative life cycle carbon emissions of different vehicle options, Ford has developed a carbon emissions calculator. Currently used by Ford's National Account Managers with their fleet customers, this calculator helps customers assess the well-to-wheels emissions benefits and fuel costs of alternative fuel vehicles. For more information on this calculator, please see our Ford Fleet Purchase Planner case study.

Energy Security Benefits of Electrified Vehicles

The current energy demand for transportation is almost exclusively met by petroleum. Globally, approximately 94 percent of transportation energy demand is provided by petroleum. The near-complete dependence of a vital economic sector on what in many places is an import-dominated energy resource is clearly an issue of concern. One of the major benefits of increasing the proportion of electrified vehicles is that it will diversify the transportation energy demand and provide increased energy security. Hybrid electric vehicles (HEVs) reduce petroleum demand by increasing efficiency. PHEVs reduce petroleum demand by increased efficiency and also by switching some of the energy demand from petroleum to other sources. PHEVs offer flexibility in fuel choice, while BEVs remove the need for petroleum entirely.

The U.S. currently imports approximately 40 percent of its petroleum consumption, though this figure is declining as U.S. oil and gas production increases. The increased electrification of the U.S. vehicle fleet will decrease petroleum demand and accelerate the transition to a more energy-secure future.

Maximizing Vehicle Efficiency

Electric vehicles are inherently more efficient than gasoline vehicles. In addition, electric vehicles do not consume energy while at rest or coasting, and approximately 95 percent of the braking energy is recaptured at each stop.

Ford has made it a priority to further maximize the efficiency of our electric vehicles. We optimized every system in the vehicle to ensure it would be as efficient as possible. In addition to using the latest technology for the battery and the rest of the electric-drive components, we have maximized efficiency through improved aerodynamics and low rolling resistance. And, we used our knowledge from two generations of hybrid electric vehicles to enhance the Focus Electric's range and efficiency through regenerative braking.

Maximizing Driving Efficiency

Our in-vehicle information systems also help drivers to increase the distance they can go on a single charge and reduce the overall costs of operating an EV by helping them drive as efficiently as possible. Our electric vehicles can coach drivers on how to maximize efficiency by focusing on the "ABCs" of efficient driving: acceleration, braking and cruising. These tools also help drivers to maximize their driving range. See Living the Electric Lifestyle for more information. We are also working on future vehicle technologies that will help reduce emissions related to idling in congestion and driving unnecessarily to find parking. Up to 20 percent of a vehicle's lifetime emissions may come from driving around looking for a parking space. For more information on our work to develop new mobility solutions please see the Mobility section.

Maximizing Charging Efficiency

As described previously, we are encouraging drivers to switch to Level 2 chargers to increase charging efficiency and driver satisfaction with their plug-in vehicles. However, many of the most important strategies for maximizing the efficiency and environmental benefits of electric vehicle charging require changes to the electrical grid and the fuels used to power it. While these issues are mostly beyond Ford's control, we are working with utilities and municipalities to make the most of electric vehicles' advantages, as discussed below. (See also the Improving the Electric Vehicle Ecosystem section.)

Using Renewable Energy: As the power-generation sector continues to improve its fuel mix, the environmental impact of driving a plug-in vehicle will diminish substantially – perhaps even toward zero. But adding more renewable fuel sources to electrical grids will take time. As this evolution takes place, smart vehicle-to-grid communication systems can help utilities better use the renewable energy sources that are accessible. For example, such systems can allow vehicles to charge when wind power is most available (usually at night) or during the day from solar arrays, depending on the renewable source available and its output.

In addition, home-based solar power is becoming more affordable. Solar power in general has dropped from approximately $6 per watt of capacity in 2011 to $2 to $3 per watt in early 2013. In states with home solar power incentives, customers may be able to lease solar energy systems at a price that is lower than their current monthly electric bill, with no upfront cash.

Ford is working with utility partners to develop home-based solar recharging stations that will allow EV owners to obtain the power they need to charge their vehicles from renewable sources, even if the overall electricity grid has not changed. Our research shows that nearly 40 percent of EV customers either have solar power or plan to purchase it within a year. We have partnered with SunPower Corp. to offer customers the **Drive Green for Life** program, which includes a home rooftop solar system that can provide enough clean, renewable energy to offset the electricity used to charge the car. The 2.5 kW rooftop solar system is backed by a 25-year limited warranty and produces an average of 3,000 kilowatt hours of electricity annually. The high-efficiency panels generate approximately 50 percent more electricity than conventional panels and utilize a smaller footprint on the roof. The system is sized to provide the electricity needed to drive about 1,000 miles per month or 12,000 miles per year. We are working with SunPower to ensure that the unit is competitively priced. We are also providing additional incentives to customers who work with Ford dealers to start the process of getting this solar power system.

"Smart Grids and Smart Charging": The development of smart grid technologies, which can provide utilities and customers with real-time information on energy use and energy prices, is a key enabler of the efficient integration of electric vehicles and grids, and an important strategy for maximizing EV efficiency and environmental benefits. Smart grids will help make the electrical grid and electrical vehicle charging more efficient by channeling vehicle charging to times when electrical grid resources are currently underutilized. Since demand for electricity fluctuates (generally peaking in the afternoon and dropping off at night), utilities typically use a mix of fuels and power plant types to meet demand. That means the environmental impacts of electric vehicle use will vary depending on where and when the vehicles are charged. During certain seasons and particularly at night, utilities generally have excess generation capacity – unused resources that create financial inefficiency. Charging PHEVs and BEVs during these off-peak hours, when this excess capacity is available, can increase the overall efficiency of the electric grid – potentially reducing CO_2 emissions, as well as the cost of electricity for all utility users. If PHEVs and BEVs are charged at peak times, that could create increased CO_2 emissions from power generation and also create demand for additional power plants. Utilities have a role to play in educating electrified-vehicle users and providing them with incentives to charge their vehicles at the most beneficial times.

Smart meters are a key element of smart grids. Smart meters allow two-way communication between homes and their electric utility, and also between "smart" equipment in customers' homes (such as plug-in vehicles) and the utility. Smart meters facilitate "smart vehicle charging" during lower-cost, off-peak times.

Value Charging: Value Charging, a feature available on Ford's electrified vehicles in the U.S., also helps to maximize the efficiency of charging and the environmental benefits of EVs. This system contains information on local utility rates and off-peak times to charge, which helps to prevent the need for infrastructure upgrades to support added energy demand and reduce the production of additional CO_2. Ford will to continue to work with utility partners and municipalities to help further develop systems to maximize the effectiveness of electric vehicles and their interaction with the electricity grid.

A Holistic Environmental Approach

Reducing emissions and maximizing vehicle efficiency are just some of the elements of our strategy to maximize the environmental benefits of EVs. We are also using green power and green technologies to manufacture our EVs, as well as green materials in our electrified vehicles and charging stations.

The Michigan Assembly Plant, for example, which produces the Focus Electric, C MAX Energi and C MAX Hybrid, in addition to the standard gas-powered Ford Focus, is powered by one of the largest solar arrays in the state of Michigan. We partnered with DTE Energy to install this solar panel system at the plant. We are also working with DTE Energy to develop a stationary battery energy storage system that will store excess power produced by the solar array until it is needed in the plant. This battery storage system uses electric vehicle batteries that have reached the end of their useful lives in vehicles. This approach provides a second life for vehicle batteries, which reduces waste and maximizes the efficiency of solar power. The Michigan Assembly Plant also uses power generated from the methane released from decaying trash at a nearby landfill, which reduces emissions of this potent greenhouse gas. And the plant uses battery-electric-powered tugs, converted from diesel power, to move vehicles and parts around the plant. The tugs are powered directly from the solar array, and when not in use the remaining energy stored in the tug batteries is discharged into the 750 kW battery bank.

The Michigan Assembly Plant – which produces the Focus Electric, C MAX Energi, C MAX Hybrid and gas-powered Ford Focus – is powered by one of the largest solar arrays in the state of Michigan.

Ford is also using green materials in our HEVs, BEVs and PHEVs, as well as many of our other vehicles. For example, our existing HEVs use recycled-content seat fabrics. Since 2011, all of our U.S. vehicles, including our electrified vehicles, have used soy foam. For more information about our use of green materials in vehicles, please see the Sustainable Materials section.

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1. Joseck, F., and Ward, J., Cradle to grave lifecycle assessment of vehicle and fuel pathways, DOE Program Record 14006, (2014). See http://www.hydrogen.energy.gov/pdfs/14006_cradle_to_grave_analysis.pdf.
2. This CO_2 reduction value is a “net” well to wheels value based on the reduction in CO_2 emissions resulting from the greater efficiency of the electric versus the gasoline engine. But it also accounts for the fact that the grid electricity that is being used to recharge the vehicles also produces upstream CO_2 emissions. All-electric miles driven are calculated from data collected through the MyFord Mobile database.

Improving Electrified Vehicle Affordability

The current cost to make plug-in vehicles is substantially higher than that of conventional vehicles, largely due to the cost of batteries. Depending on the price of electricity and gasoline, however, the energy cost to operate an all-electric car is in the range of 3 to 4 cents per mile, compared to about 8 to 16 cents per mile[1] for a conventional gasoline-powered vehicle. So, lower operating costs can help to offset the higher initial purchase price of electric vehicles (EVs).

To develop next-generation electrification technologies and electrified vehicles, automakers and their suppliers will need to invest billions of dollars. In addition, utilities will need to invest to increase electricity generation and transmission capacity, with generally higher costs for green electricity sources. Governments will also need to invest by encouraging and facilitating the development of technology and infrastructure, and providing incentives for consumers to buy EVs. At present, Ford is doing what it can to reduce the costs of manufacturing and operating EVs.

Reducing Vehicle Production Costs

We have planned our electric vehicle strategy based on our highest-volume global platforms, which can help to reduce the costs of electric vehicles by creating economies of scale. For example, the Focus Electric, C MAX Hybrid and C MAX Energi plug-in hybrid are all based on our global C-platform, which we expect to underpin 2 million vehicles annually.

We are using best-in-class flexible manufacturing technology in our Michigan Assembly Plant, which produces the Focus Electric, C MAX Hybrid and C MAX Energi, as well as the gas-powered Focus. Flexible manufacturing allows us to switch production between different vehicles to meet changing customer demand without retooling our plant or assembly lines – a significant cost reduction. This is important in helping us respond nimbly to a changing market.

Ford is working with a range of battery suppliers and other partners to develop next-generation battery technologies that will help to bring costs down. Please see the Battery Technologies section for more information on advanced batteries for EVs.

Reducing Vehicle Operation Costs

The fuel costs of battery electric vehicles (BEVs) are significantly lower than for gasoline-powered vehicles. EVs require less energy to move a given distance, compared to conventional gas-powered vehicles. The average price for residential electricity in the U.S. is about 12 cents per kilowatt-hour. The fuel cost to travel 80 miles in a Focus Electric with a combined fuel economy of 105 MPGe is about $3. Driving 80 miles in a highly fuel-efficient, competitive gasoline-powered vehicle that gets 40 mpg would cost about $8 (assuming $4 per gallon of gasoline) – approximately three times more than the EV. If drivers use Ford's Value Charging, the cost of traveling 80 miles in the Focus Electric drops even further to approximately $1 to travel 80 miles.

We are taking a range of steps to further reduce the operating costs of EVs to help offset their higher purchase price.

Through Value Charging, for example, we are helping EV owners find the most efficient times to charge their vehicles. This system helps customers reduce their electricity costs by taking advantage of off-peak or other reduced utility rates without a complicated setup process.

The MyFord Touch®-based in-vehicle communications systems on our electric vehicles, described in Living the Electric Lifestyle, also help reduce EV operating costs by enabling drivers to maximize their driving efficiency and in-vehicle energy use.

Our BEVs will also have lower maintenance requirements than gas-powered vehicles. The Focus Electric eliminates more than two-dozen mechanical components that would normally require attention during the life of the vehicle. So, for example, drivers won't have to change oil, oil filters, fuel filters or spark plugs, or worry about a worn out muffler or serpentine belt. Based on a regular oil change maintenance schedule, Focus Electric owners will save approximately $500 over the 150,000-mile life of the vehicle on oil change costs alone.

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1. Assuming an energy consumption of about 3 to 4 miles/kWh at 12 cents/kWh for the electric vehicle, and a fuel economy of 40 miles/gallon at $3 to $5/gallon for the gasoline vehicle.

Battery Technologies

Ford's Approach to Advanced Technology Batteries

All of Ford's newest electrified products use lithium-ion batteries, which offer a number of advantages over the nickel-metal-hydride batteries we used in the past. For example, they are generally 25 to 30 percent smaller and 50 percent lighter, making them easier to package in a vehicle.

The Focus Electric is powered by a lithium-ion battery system that utilizes cooled and heated liquid to regulate battery temperature, extend battery life and maximize driving range. The innovative thermal management technology helps the Focus Electric operate efficiently in a range of ambient temperatures. Advanced thermal management of lithium-ion battery systems is critical to the success of pure electric vehicles, because extreme temperatures can affect performance, reliability and durability.

We continue to research and develop improved battery technologies to make battery-powered vehicles even more efficient and affordable and allow them to go farther on a single charge. In 2013, we opened a new battery research center with the University of Michigan that allows Ford to collaborate with battery cell manufacturers, suppliers, university researchers and start-ups to test new battery concepts on a small scale that could be replicated for full production.

Ford is also assisting in developing end-of-life recycling infrastructure in the U.S. for nickel-metal-hydride and lithium-ion batteries, both of which are high-voltage batteries. For example, we are providing educational material on battery removal, transportation and recycling, as well as a call center for end-of-life vehicle dismantlers through the End of Life Vehicle Solutions Corporation (ELVS). (The ELVS, of which Ford is a participating member, was created by the automotive industry to promote the industry's environmental efforts in recyclability, education and outreach, and the proper management of substances of concern.) We are also connecting scrap buyers with dismantlers who have high-voltage batteries to recycle. In addition, Ford is working with DTE Energy to develop stationary energy storage systems from vehicle batteries that have reached the end of their useful life in vehicles. Ford engages with all the parties that handle end-of-life batteries, including customers, local authorities, emergency services (e.g., tow trucks and first responders), dealerships, independent workshops and garages and vehicle recyclers. Customers can recycle their batteries with local recyclers or bring them to any Ford or Lincoln dealer for no-cost recycling.

Supply Chain Issues

As the widespread electrification of automobiles moves closer to reality, a new set of concerns is emerging regarding the environmental and social impacts of extracting and processing key materials needed to make electric vehicles. For example, there are concerns about rare earth metals, which are used in electric motors for vehicles, wind turbines and other advanced technologies; also, a better understanding of mining processes is required.

Significantly accelerating the production of electric vehicles is likely to require the use of much greater quantities of lithium and rare earth metals. Currently, production of these resources is concentrated in a few countries, including Chile, Bolivia and China, which has led to questions about the adequacy of the supply of these resources and the potential for rising and volatile prices as demand puts pressure on existing supplies. In addition, there are concerns about geopolitical risks posed by the limited availability of these materials. Could we be trading dependence on one limited resource (petroleum) for another? Finally, the use of water in the production of these materials needs to be considered.

We take these concerns very seriously. With scientists at the University of Michigan, we have conducted and published a study of lithium availability and demand. We found that there are sufficient resources of lithium to supply a large-scale global fleet

Related links

This Report

Supply Chain
Water

of electric vehicles through at least the year 2100.[1] We conducted a study of rare earth element availability and demand with scientists at the Massachusetts Institute of Technology. We found that absent efficient reuse and recycling or the development of technologies which use lower amounts of dysprosium (Dy) and neodymium (Nd), following a path consistent with stabilization of atmospheric CO_2 at 450 ppm might lead to an increase of approximately 700 percent and 2600 percent in the use of these two elements, respectively, over the next 25 years if their present needs in automotive and other applications are representative of the future needs.[2]

Ford generally does not purchase raw materials such as lithium and rare earth metals directly – they are purchased by our suppliers (or their suppliers) and provided to us in parts for our vehicles. As described in the Supply Chain section of this report, our contracts with suppliers require compliance with the legal requirements of Ford's Policy Letter 24: Code of Human Rights, Basic Working Conditions and Corporate Responsibility and the adoption of a certified environmental management system (ISO 14001). We are working in our supply chain to build the capability of our suppliers to provide sound working conditions in their operations. We ask the suppliers we work with to take similar steps with their suppliers. We are also working cooperatively with other automakers to extend this approach through the entire automotive supply chain.

As part of our water strategy, we are working with colleagues at the Georgia Institute of Technology to evaluate the water requirements and impacts of powering vehicles with conventional fuels, biofuels and electricity. This work includes a study of the water requirements of lithium extraction and processing, which, based on our understanding of the extraction of lithium from brines in arid areas, we anticipate will be low.

We will continue to monitor and assess these issues for their potential impact on our electrification strategy and our sustainability commitments.

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1. P. Gruber, P. Medina, S. Kesler, G. Keoleian, M.P. Everson, T.J. Wallington, Global Lithium Availability: A Constraint for Electric Vehicles?, J. Industrial Ecology, 15, 760 (2011).
2. E. Alonso, A.M. Sherman, T.J. Wallington, M.P. Everson, F.R. Field, R. Roth and R.E. Kirchain, Environ. Sci. Technol., 46, 3604 (2012).

Improving the Electric Vehicle Ecosystem

We are collaborating with consumers, municipalities, utilities, and other supporting industries to develop an "electric vehicle ecosystem" that can support and enhance the operation of EVs and help deliver greater benefits to customers and the environment. For example, we are working with utilities and municipalities to address impacts of EVs on the electrical grid. We are also working with other industry partners to maximize the efficiency and benefits of charging EVs for vehicle owners.

Working with Utilities and Municipalities

If EVs are charged during times of peak electricity demand, they may stress the current grid and require the construction of additional electricity supply. Furthermore, charging vehicles during peak demand would significantly reduce the operating cost benefits expected from electric vehicles. "Smart grid" technology that allows communication between recharging vehicles and the electrical grid provides a key opportunity to maximize recharging efficiency and minimize stress to the grid. Automakers and utilities must continue to work together to develop this "smart" vehicle-to-grid communication system. Overcoming these challenges will require significant collaboration between automakers, electric vehicle supply equipment manufacturers, electric utilities, regulatory agencies and legislators.

Because utilities and automakers have not had to work together in the past, effective collaboration requires developing new relationships and learning about each other's business and regulatory challenges. For example, utilities and automakers have very different business models: utilities operate regionally and have little to no direct competition within their markets, while automakers operate and compete globally. Furthermore, automakers are primarily regulated at the national level, while utilities face more local and state regulations, which increases the difficulty of establishing a national strategy for vehicle-to-grid interaction. It will be important for automakers and utilities to understand and address these kinds of differences as they work together on vehicle electrification issues.

Initially, much of our work with utilities was focused on demonstration and testing projects to help develop the best path forward for large scale deployment of plug-in vehicles. From 2007 to 2012, Ford worked with the Electric Power Research Institute (EPRI) and several utilities on a U.S. Department of Energy funded project to assess the performance and charging options for plug-in hybrid electric vehicles (PHEVs). The projects included testing PHEVs in over 800,000 miles of real-world driving and conducting vehicle-to-grid connectivity testing with "smart meter" technology. Lessons learned from this testing, as well as from the entire demonstration, helped support the production introduction of our two plug-in hybrid electric vehicles: the Ford C MAX Energi and the Ford Fusion Energi.

We are continuing this demonstration and testing work in Europe. In Germany, Ford is working with 12 other partners on the colognE-mobil program, using a fleet of 66 electrified vehicles – including Focus Electrics and C MAX Energi plug-in hybrids – to conduct road testing. The partners are examining further aspects around e-mobility in the area of Cologne, integrating regional and supra-regional traffic and public transport. The goal of this project, is to examine interlaced and marketable solutions for electrically powered vehicles as well as the appropriate charging infrastructure in the Rhine Ruhr region. In addition to Ford, the partners include a local energy provider, a solar energy company, public transport providers, as well as a university and research agencies. This program is part of a much larger research effort in several German cities that is partly funded by the German government and involves multiple automakers, utility companies, universities and technology partners.

In the U.S., we are working with utilities, municipalities and states across the country to develop and facilitate the use of EV implementation best practices. For example, in 2013, we joined EV-related collaborative in California, Oregon, and Florida. These collaboratives include representatives from local government, utilities, automakers, and other industry players who are working to implement EVs. Some of the key issues we are working on with local utilities and municipalities include the following:

- **Time-of-use electricity rates:** We are encouraging utilities to adopt a "time-of-use" rate structure, which would enable them to charge different rates at different times of the day based on overall electricity demand. Under a time-of-use structure, electricity rates would be lower at night when there is lower demand on the electrical grid. Since most EVs charge at night, this increases the benefits of electrified vehicles for consumers. For example, a 20-mile trip on electricity at national rates of 0.12 cents/kWh costs about $1. If a customer is able to switch to a time-of-use rate, this trip could cost as little as 50 cents. Time-of-use rates also help utilities by giving customers an incentive to charge at times when electrical demand is already low, which helps to balance out utilities' electrical loads.
- **Maximizing the publicly accessible recharging infrastructure:** We are working with municipalities and utilities to develop additional public recharging stations and to encourage a thoughtful and holistic approach to planning for publicly accessible charging. PlugShare, a website that tracks publically accessible charging stations, currently includes about 24,000 public charge stations in cities throughout the U.S. and Canada, up from about 16,000 in 2013 and just 5,000 a few years ago. This is an important step in fostering electrified vehicle use. However, the placement and design of publicly accessible charging stations requires careful consideration to maximize their usefulness to EV drivers. We are endorsing a holistic urban-planning approach to charging station development in which local officials actively plan the locations for publicly accessible EV charging based on traffic patterns and the locations of other charging stations. This kind of approach will result in charging locations that are used more often and will make more efficient use of investment dollars. We are also encouraging standard rules and signage for public refueling infrastructure that would tell drivers what type of charging is available, the hours when EVs can use charging stations, the length of time an EV can remain plugged in and how rules for charging stations are enforced.
- **Standards for private, third-party charging stations and the resale of electricity:** In many cases, publicly available refueling stations will be installed and run by private businesses, such as gas stations and restaurants. In most states, when a third party resells their electricity, as they would to an EV driver, they are considered a regulated utility and face the same stringent regulations a utility must follow. We are working with states to encourage updating regulations so that reselling electricity for transportation would not be subject to utility-like regulations. This will encourage the development of more publicly accessible recharging stations.
- **Home EV charging station permitting process:** Homeowners are required to get a permit from their municipality and/or utility to install a home EV charging station. Historically this process can take more than two weeks. We have been working with utilities and municipalities to encourage modifications to streamline the permitting process to make it easier and shorter for consumers.
- **Promoting EV incentives:** Through our work with cities and utilities, we have identified a range of actions that will help consumers make the transition to electrified vehicles – for example, infrastructure incentives to offset a portion of customer costs for hardware and installation.
- **Building codes for new construction:** We are working with municipalities to develop codes for new building construction that would make them "EV ready," with best practices such as wiring for EV chargers.

We are working on these issues in a variety of ways, including with utilities and municipalities in key EV markets across the U.S. We are also serving in a formal advisory role to utilities in several states. Ford is also an active member of the Electric Drive Transportation Association, an industry group that is working to implement EVs in the U.S. And, we are testifying before state legislatures around the country to endorse legislation that will facilitate the successful implementation of EVs.

Our collaborations with utilities and municipalities are yielding key lessons that we are incorporating into our continued efforts to make electrified vehicles successful in the real world. Some of the key learnings so far include the following:

- Electric vehicles provide additional impetus to develop smart communication systems between vehicles and grids. These systems will allow the consumer to know if and when lower electricity rates are available and help prevent additional loads on the infrastructure. Smart communication systems could alleviate the need for expensive infrastructure upgrades, the costs of which may be passed back to customers by utilities (e.g., if a transformer needs to be upgraded).
- Smart vehicle charging will require that utilities and automakers develop a common standard for vehicle-to-grid and grid-to-home meter communications. Currently, utilities tend to operate regionally, but electric vehicles will increase the need for common national and even international standards. We have worked to develop a common charging standard in the U.S., and we are now

focused on fostering the development of an internationally common charging standard.

- Widespread use of electric vehicles will likely require that vehicle power consumption be measured separately from home electricity use, requiring either additional meters or smart meters. In addition, the pooling of electrified vehicles in a particular region may require upgrades to the transformers and/or substations that form the electrical grid in that area. Utilities are already installing smart meters at a rapid pace. There are interesting possibilities for vehicle-to-grid and vehicle-to-home power flow. However, there are also significant challenges to making these possibilities a reality. For example, technical, safety, codes/standards compliance, legal, robustness and business case issues need further study prior to commercialization.
- Vehicle owners will likely want to be able to charge their vehicles at any geographic location and – in those cases where another payment method isn't used – have the cost applied to their home energy bill. In addition, vehicle identification and home meter association must be seamless for the customer. This kind of mobile or remote billing for vehicle charging services will require a paradigm shift in the utility industry's current billing processes and tools.
- Automakers and utilities both benefit from working together on outreach to local, state and federal regulators and legislators. Ford and our utility partners are already working with legislators and regulators on national standards for vehicle charging infrastructure, and incentives and strategies to bring costs down.
- Utilities and automakers need to work together to educate consumers about the differences between electric vehicles and traditional vehicles so that consumers understand how to make the most of electric vehicles and charging infrastructure.

We are also working to develop common charging technology for electric vehicles so that all electric vehicles will be able to use a common plug-in charging system for both AC and DC fast charging. In North America, the Society of Automotive Engineers, with Ford's participation, successfully developed and approved a standard charge connector and communication protocol, enabling all plug-in vehicles to use common charge points. This will be a key enabler for adoption in North America; the same connector is under consideration in other global markets.

Expanding Workplace Charging

As part of our effort to expand EV charging infrastructure, we signed onto the U.S. Department of Energy's pledge to increase vehicle charging infrastructure available in workplaces across the country in January 2013. The Workplace Charging Challenge is a collaborative effort to increase the number of U.S. employers offering workplace charging by tenfold in the next five years. As part of this program we are installing 180 electric vehicle charging stations at nearly every Ford facility – including company offices, product development campuses and manufacturing facilities – in the U.S. and Canada throughout 2014. Our employees will be able to charge the all-electric Focus Electric and the Fusion Energi and C MAX Energi PHEVs at the charge stations to increase the number of all-electric miles driven. The service will initially be free to employees for the first four hours of each day. Our workplace charger installation is different from other automotive companies' because the chargers will be networked together. As a result, Ford will be able to gather information on electrified vehicle use, such as the number of hours vehicles are charging and the amount of CO_2 reduced. Ford will work with GE as its network provider and supplier of electric vehicle charging stations.

Working with Other Industries through the MyEnergi Lifestyle Project

The continued adoption of plug-in vehicles that share the same energy source (electricity) as the home creates a unique convergence between the transportation and residential sectors. In 2013 we launched the MyEnergi Lifestyle project to demonstrate how plug-in vehicle technology can be applied in conjunction with efficient household appliances and renewable energy generation for an energy- and money-saving lifestyle.

The Ford-led project, which currently includes Whirlpool, Eaton, Infineon, SunPower and the Georgia Institute of Technology, shows that more efficient and coordinated use of home electricity for appliances and electric vehicles can, on an annual basis, reduce a home's electricity use by up to 55 percent, reduce users' electricity bills by up to 60 percent, and reduce electricity-based home carbon dioxide emissions by up to 56 percent.

Initially, these results were based on computer simulation of an average American home developed in partnership with the Georgia Institute of Technology. The model compared two scenarios: (1) an average home with appliances from 1995, two gasoline vehicles with a fuel economy of 25 miles per gallon each, no solar power, and no intentional off-peak electricity usage, and (2) a home with 5 kW of SunPower solar panels installed on the roof, one gasoline vehicle replaced by a Ford Focus Electric, all appliances replaced by 2012 Whirlpool appliances (including refrigerator, hot water heater, dishwasher and clothes washer/dryer), and a shift in home energy usage (including EV charging) to take advantage of time-of-use (Value Charging) reduced rates.

Over the course of 2013, these model-based results were confirmed in the real world by families participating in this program. For example, one participating family realized more than $1,200 saved in annual fuel costs with their C MAX Energi. They expect to save more than $300 annually from their new solar panel system and the system offsets more than 70 percent of the energy used in their home. They have also seen a more than 25 percent reduction in energy costs and CO_2 due to the installation of their new energy-efficient Whirlpool refrigerator.

In 2014, we upgraded the program to include battery storage technology to store power generated by solar panels or other renewable energy systems.

These improvements would be hugely significant if implemented on a broader scale. If every home in the U.S. were to implement these energy-saving technologies, it would be equivalent to eliminating the electricity usage of more than 32 million homes (or all the homes in California, New York state and Texas combined). For more information on this project please see myenergilifestyle.com

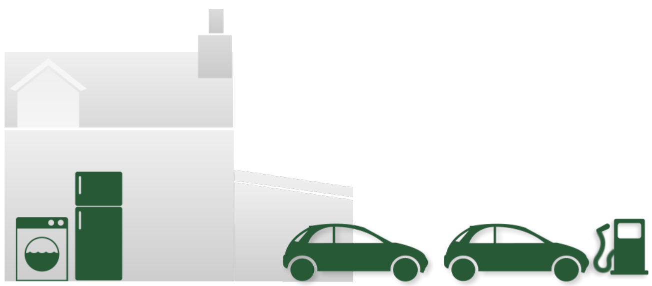
MyEnergi Lifestyle

New technology is enabling American families to reduce their electricity bills and CO_2 footprint by integrating a plug-in vehicle, energy-efficient appliances, renewable energy sources and cloud computing that takes advantage of lower off-peak electricity rates.

Average U.S. home

11,000kWh

of electricity used every year

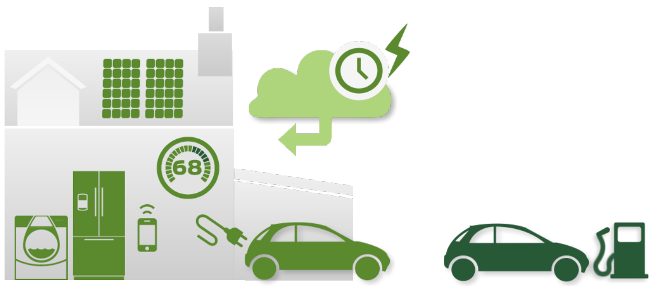


MyEnergi Lifestyle home

Reduces energy costs by

60%*

If implemented in every home in the U.S., these technologies would save the equivalent of the electricity usage of 32 million homes, or approximately the total number of homes in California, New York, and Texas combined.



* Comparing 1995 appliances and a 25 mpg vehicle to 2012 appliances and a Ford C MAX Energi plug-in hybrid vehicle with value charging.

Greening Our Operations

We have adopted a rigorous and holistic approach to reducing the overall environmental impacts of our manufacturing facilities. As part of this strategy, we have established global facility environmental targets that address the range of our environmental impacts, including energy use, emissions, water use and waste generation. Our global, company-wide targets include:

- Reducing greenhouse gas emissions from our manufacturing facilities by 30 percent per vehicle produced from 2010 to 2025
- Reducing average energy consumption per vehicle produced by 25 percent globally from 2011 to 2016
- Reducing water use per vehicle produced by 30 percent between 2009 and 2015
- Reducing waste to landfill per vehicle produced by 40 percent between 2011 and 2016

We made progress toward meeting each of these goals in 2013 including:

- Reduced CO_2 emissions from our manufacturing facilities per vehicle produced by 9 percent compared to 2012.
- Reduced average energy consumed per vehicle produced by 4 percent compared to 2012.
- Reduced water use per vehicle produced by 5 percent compared to 2012, and met our 2015 target two years early.
- Reduced waste to landfill per vehicle produced by 14 percent compared to 2012.

This section reports on our facilities' environmental performance, including operational energy use and greenhouse gas emissions, non-CO_2 facilities-related emissions (including volatile organic compounds), water use, waste management, sustainable land use and biodiversity, compliance and remediation.

Facilitating and Measuring Progress

In addition to our global, company-wide environmental performance goals, each Ford facility also has a comprehensive set of environmental targets and uses a detailed scorecard to report against these targets, so that we can track and accelerate improvements. Progress toward the targets is reviewed throughout the year by senior management at regular Business Plan Review meetings. In addition, these targets become part of the performance review metrics for every plant manager and regional manufacturing manager, as well as others in the management hierarchy up to the executive vice president of manufacturing and labor affairs. For more information on our overall sustainability governance, integration and management processes, please see the Governance section.

We have developed a series of tools and processes to manage environmental issues in our operations that help us facilitate and measure progress on key issues including energy use, water use, and waste generation and disposal. These tools help us accomplish four tasks that are central to advancing and measuring our progress on environmental issues:

- Setting corporate-, regional- and facility-level performance goals and targets;
- Managing internal and external goals, targets and regulations;
- Evaluating, standardizing and spreading the use of best practices across our facilities to help us meet performance goals; and
- Tracking performance using accurate and standard data to help us assess and improve performance.

Environmental Operating System – managing environmental performance goals, targets and regulatory requirements

Ford's Environmental Operating System (EOS), which is fully aligned with the Ford Production System (FPS), provides a standardized, streamlined approach to maintaining compliance with all legal, third-party and Ford internal requirements, including government regulations, ISO 14001 and Ford's own environmental policies, and business plan objectives and targets. In addition to facilitating compliance with external regulations, the EOS also helps us develop and track internal environmental performance goals at the corporate, regional and facility level.

Energy Management Operating System – managing energy-related goals, targets and performance improvements

In 2013, we finalized the global rollout of our Energy Management Operating System (EMOS). We developed this system to provide a common and global structure to support and maintain energy-reduction actions, to achieve the corporate goal of improving global energy use per vehicle produced by 25 percent between 2011 and 2016. The EMOS is our mechanism for integrating energy-efficient principles into the facility design, manufacturing/engineering processes, and operations of Ford Manufacturing, Office and Engineering facilities. The system is aligned with our Ford Production System (FPS) and ISO 14000/50001 principles, and it leverages existing lean manufacturing principles including Plan-Do-Check-Act (PDCA) protocols and Six Sigma tools.

Plant Energy Teams lead the implementation of the EMOS. At each plant, an energy management team develops a plant-level energy road map, which provides an overview of planned energy actions and a forecast of how well the plan will meet the corporate energy reduction objective. As an input to the road map, the energy team performs an "energy health assessment," which evaluates the plant's operational performance, provides comparisons to other plants, and provides a list of best practices the plant can use to improve energy efficiency. Plant startup and shutdown processes are a key area of focus for energy teams, as these processes have significant impacts on plant energy use and provide major opportunities for energy use reduction. The team is also responsible for "energy opportunity evaluations," which seek to identify additional opportunities to further improve energy efficiency beyond those provided in existing best practice lists. These additional efficiency opportunities could be based on peculiarities of the specific plant or they could be new ideas that contribute to future best practices that might be implemented in other plants as well.

In addition to the Plant Energy Teams, the EMOS also includes three other teams of people working cooperatively to support the work of the Energy Teams:

- Facility Changes – this group is responsible for spreading best practices across Ford facilities by developing standards and specifications that are used in planning for the future (both facility and process) and getting the standards embedded into future product/project plans.
- Data Management – this group ensures robust and timely data for reporting and analysis to support Plant Energy Teams and other decision-makers.
- Energy Supply and Quality – this group addresses energy purchases to ensure reliable and low-cost energy

Global Facilities Forum – developing global standards and best practices

In 2011, we established the Global Facilities Forum (GFF) to standardize processes for construction and refurbishment of Ford facilities. The GFF includes representatives from Ford's Environmental Quality Office, which oversees the environmental performance of Ford manufacturing facilities and Ford Motor Land Development Corporation (or "Ford Land") which manages the construction of all Ford-owned facilities and the maintenance of Ford's nonmanufacturing and commercial real estate facilities. The Forum also includes representatives from each of Ford's operating regions. Before establishing the GFF, each region and operating group within Ford maintained its own set of standards, which made it more difficult to capture, record, and spread best practices and lessons learned. The GFF develops and manages facility specifications and construction practices globally to achieve cost and sustainability objectives and spread best practices across our facilities. The GFF also prioritizes incorporating energy and sustainability objectives into building standards. Another key improvement of the GFF is a focus on life cycle costs, not just first or implementation costs. This facilitates the implementation of many energy-efficiency and other environmentally preferable strategies, as well as reducing total costs to the company. This standardization of best practices, especially environmental best practices, is becoming increasingly important as Ford continues significant investments in new facilities in Asia and refurbishing existing facilities in the United States.

Facility Performance Improvement – setting goals and performance improvement plans for existing plants

We implement year over year, internal facility-level goals at our existing plants for environmental performance in key areas, energy use, carbon dioxide (CO_2) emissions, waste to landfill, water, and volatile organic compound (VOC) emissions for assembly facilities and hydrocarbon use for powertrain facilities. Through this program we determine the Ford plant with the best performance in each of these areas and set annual improvement targets for other plants based on ultimately meeting this stretch goal. In addition to setting internal facility goals, we also develop a road map for each facility to help them meet these goals. For example, through this program, we identify best practices plants have used to achieve their excellent performance, we evaluate these best practices for replication at other facilities, and we communicate best practices through a "single point lesson" system. This process will be fully implemented globally in 2014.

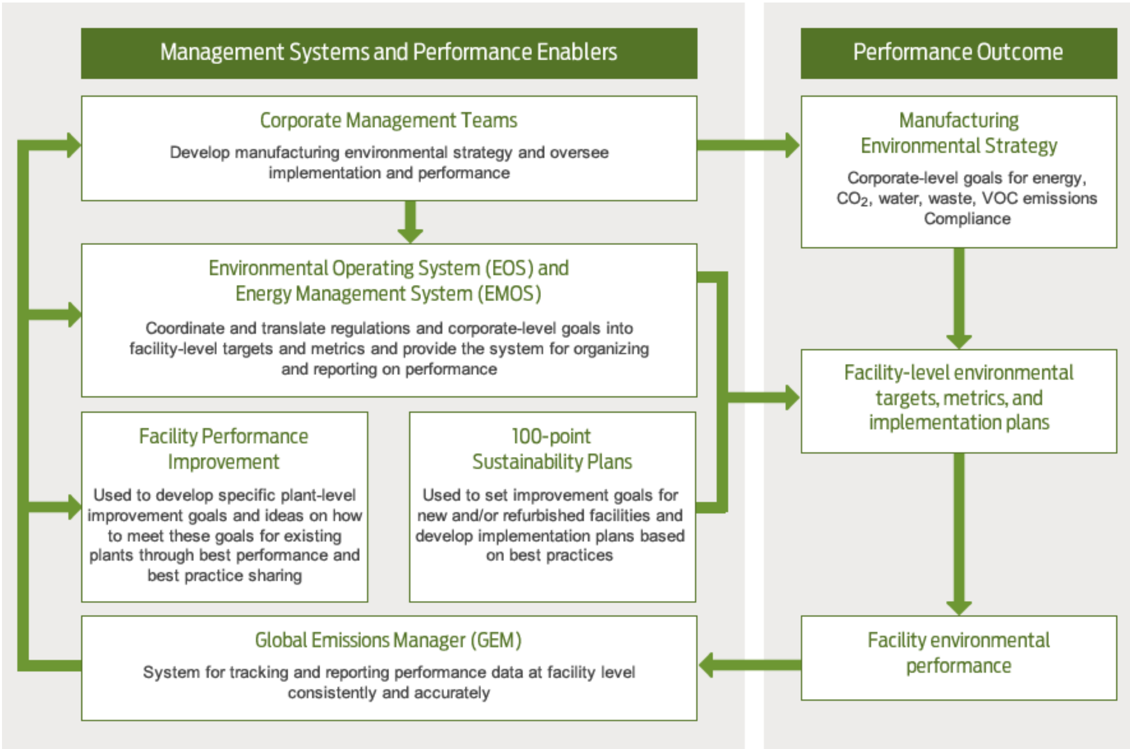
100 Point Sustainability Program – setting goals and performance improvement plans for new or refurbished plants

We use a 100 point sustainability program to incorporate environmental performance best practices into new plants, plants that are being renovated for a new vehicle programs, and plants that are otherwise being refurbished. We have established a rating system for each plant for each of several key environmental areas – energy, CO_2 emissions, water, waste to landfill, and VOC emissions for assembly facilities and hydrocarbon use for powertrain facilities – and a rating for each major action taken to achieve performance improvements in these areas. These initial ratings provide a baseline for future improvements and provide a way to prioritize different improvement actions. We then set point-based improvement targets for new plants and existing plants that are being retooled for a new vehicle program or otherwise being refurbished as part of the product development and budgeting process. These targets include a road map of specific actions to reach the sustainability point targets for each area.

Global Emissions Manager – measuring performance to track progress

To facilitate performance tracking, we launched the Global Emissions Manager database (GEM) in 2007. This industry-leading database provides a globally consistent approach for measuring and monitoring environmental data, which helps us track and improve our efforts to reduce water use, energy use, CO_2 emissions and the amount of waste sent to landfill. GEM also provides a library of environmental regulations relevant to each plant, significantly increasing the efficiency of tracking and meeting those regulations.

Facilities Environmental Management Systems



Operational Energy and Greenhouse Gas Emissions

Ford has been a leader in facilities-related greenhouse gas (GHG) and energy-use reductions, public reporting of our GHG emissions and participation in GHG-reduction and trading programs.

In 2010, we adopted a goal to reduce our facility carbon-dioxide (CO_2) emissions by 30 percent per vehicle produced by 2025. This CO_2 goal, which is also based on our stabilization commitment, complements our long-standing facility energy-use reduction targets. The U.S. Environmental Protection Agency (EPA) awarded Ford a Goal Setting Certificate for this strategy at its inaugural Climate Leadership Awards Ceremony. In 2012, Ford established a five-year objective to improve our operational energy use per vehicle produced by 25 percent globally by the end of 2016, based on a 2011 baseline normalized for weather and production.

Performance

In 2013, we improved global energy efficiency of manufacturing facilities by 17.4 percent against a 2011 year baseline normalized for weather and production levels. Our total energy use for all of our facilities increased by 6 percent in 2013 compared to 2012 due to increased production, increased number of operating facilities, and colder weather, which increases the related energy demands. However, our total energy use per vehicle produced decreased by 4 percent in that timeframe, reflecting increased overall energy efficiency in our facilities.

Similarly, our total CO_2 emissions increased slightly from 2012 to 2013 by 0.6 percent. However, our CO_2 emissions per vehicle produced decreased by 9 percent during that period, again reflecting increased overall energy efficiency in our facilities. While our CO_2 emissions are linked to the amount of energy we use, they do necessarily increase or decrease by exactly the same amount due to variations in energy sources and related emissions factors. For example, in 2013, our total facilities energy use increased by 6 percent compared to 2012, while our total facilities CO_2 emissions increased by only 0.6 percent. We reduced our overall facilities-related CO_2 emissions by 51 percent, or 5 million metric tons, from 2000 to 2013. During this same period, we reduced facilities-related CO_2 emissions per vehicle produced by 46 percent.

Please see the Climate Change and the Environment data section for more detail.

GHG Reporting Initiatives

Ford is officially “Climate Registered” after publishing its complete North American carbon inventory since 2010 with The Climate Registry (TCR), a voluntary carbon-disclosure initiative that links several state-sponsored GHG emissions-reporting efforts, including the California Climate Action Registry and the Eastern Climate Registry. Ford was the first automaker to join TCR and is one of only two automakers to be officially Climate Registered. As TCR members, we must demonstrate environmental stewardship by voluntarily committing to measure, independently verify and publicly report GHG emissions on an annual basis using the TCR’s General Reporting Protocol.

In 2013, we became the first automaker to commit to voluntarily report our GHG emissions in India. We were also the first automaker to participate in GHG reporting initiatives in China, Australia, and Mexico. We also voluntarily report GHG emissions in the U.S., Canada, Argentina, Brazil, Taiwan and Venezuela.

Since 2005, GHG emissions from our European manufacturing facilities have been regulated through the EU Emissions Trading Scheme. These regulations apply to seven Ford facilities in the U.K., Belgium and Spain.

In the U.S., many of our facilities are subject to EPA GHG reporting requirements and submit reports as required. This EPA program requires submission of annual GHG emissions report by facilities with production processes that fall into certain industrial

Related links

This Report

→ Climate Change

source categories, or that contain boilers and process heaters and emit 25,000 or more metric tons per year of GHGs.

Our participation in these reporting, emissions-reduction and trading schemes has played an important role in accelerating our facilities' GHG emissions-reduction activities.

Energy Management Initiatives

Ford is achieving energy-efficiency improvements and energy-use reductions using a variety of initiatives, many of which are described in this section. We regularly look for new technologies, approaches to the identification and definition of potential projects, funding mechanisms and means to implement plant energy-efficiency projects.

We are currently rolling out a **Global Departmental-Level Metering initiative (GDLM)** to collect electricity and natural gas consumption data at the plant level for all Ford plants globally. This system builds on the utility metering and monitoring system we have used in North America since 2007. The new GDLM program will also improve on the North American system by providing more detailed information down to the department level. We use this near real-time information to create energy-use profiles for plants and to improve decisions about nonproduction shutdowns and load shedding, which involves shutting down certain prearranged electric loads or devices when we reach an upper threshold of electric usage.

We are also upgrading and standardizing the **Building Management Systems** we use at our facilities to a new global standard. These information management initiatives will provide common reporting tools linked with production and other data sets, with facility maintenance and control systems. These efforts will greatly improve the amount of energy data we have, and the speed and quality of our energy analyses, which will help us identify energy-reduction opportunities more effectively and reduce the time required to make system changes.

In 2013, we finalized the global roll out of our **Energy Management Operating System** (EMOS), which provides a common and global structure to support and maintain energy-reduction actions, to achieve the corporate goal of improving global energy use per vehicle produced by 25 percent between 2011 and 2016. For more information on the EMOS please see the Facilitating and Measuring Progress section. In North America, we continue to use **energy performance contracting** as a financing tool to upgrade and replace infrastructure at our plants, commercial buildings and research facilities. Through these contracts, Ford partners with suppliers to replace inefficient equipment, funding the capital investment over time through energy savings. Projects have been implemented to upgrade lighting systems, paint-booth process equipment and compressed air systems, and to significantly reduce the use of steam in our manufacturing facilities. We are also expanding the use of performance contracting to global facilities using global supplier partners to accomplish the 25 percent energy-efficiency improvement objective.

In 2013, we continued to focus on **lighting as a key area for energy use improvements**. Our Global Facilities Forum (GFF) also rolled out a new global lighting specification, which requires the use of LED technology for all general building lighting requirements. We will continue to update the specification to expand the use of LEDs as the technology advances and is proven effective for our key uses. We are also working to identify other "Mega" type projects to leverage single common actions such as lighting upgrades, compressor controls, steam conversion and enhanced Building Management Systems, in partnership with our global performance contracting partners.

Since 2000, Ford has invested more than $250 million in **plant and facility energy-efficiency upgrades**. In 2013 alone, we invested more than $5 million in energy-efficiency projects and significant energy-related upgrades were included in our global manufacturing system upgrades. We are working across divisions and regions to ensure that energy efficiency is being addressed in our daily operations and incorporated into the manufacturing processes and facilities, as part of our future vehicle program plans.

In 2013, Ford joined the **U.S. Department of Energy's (DOE) Better Buildings, Better Plants program**, a national partnership initiative to drive a 25 percent reduction in industrial energy intensity in 10 years against a 2011 baseline. Twenty-four of our U.S. plants are part of this initiative.[1] We have reduced energy intensity[2] by 9.44 percent since 2011 across these 24 plants. We have reduced energy intensity by more than 15 percent at six of the 24 plants and by more than 6 percent at over half of the participating plants since 2011. We've made this progress through a number of actions including: upgraded facility lighting systems, upgraded paint process systems, installed advanced computer controls on air compressors, updated heating systems, and aggressively curtailed energy use during extended production shutdown periods.

We are continuing to replicate Ford's state-of-the-art **"3-Wet" paint process**. This technology is called "3-Wet" because the advanced chemical composition of the paint materials used allows for the three layers of paint – primer, base coat and clear coat – to be applied while each layer is still wet, which eliminates the stand-alone primer application and dedicated oven required in the conventional painting process. The 3-Wet process also saves the electricity used by the blowers that are typically needed to circulate massive volumes of air through paint booths, and reduces the amount of natural gas needed to heat the air and ovens. As a result, 3-Wet painting reduces CO_2 emissions by 15 to 25 percent and volatile organic compound emissions by 10 percent compared to either conventional high-solids solvent-borne or waterborne systems.

In addition to these environmental benefits, this process maintains industry-leading quality and reduces costs. For example, 3-Wet reduces paint processing time by 20 to 25 percent, which correlates to a significant cost reduction. Ford's laboratory tests show that this high-solids, solvent-borne paint provides better long-term resistance to chips and scratches than waterborne paint systems. In short, the process delivers reduced costs per vehicle produced, reduced CO_2, improved energy efficiency and improved quality.

Ford initially implemented the 3-Wet process at our Ohio Assembly Plant in 2007 in the U.S. Since then, we have expanded implementation across our global operations when we build new facilities or refurbish existing ones.

We have implemented the 3-Wet paint process at facilities in the United States, India, Romania, Mexico, China and Thailand. We now use the 3-Wet system at eight of our facilities globally and are expanding it to an additional four plants (two in North America, one in China and one in Spain). Three-Wet conversion will be considered for plant refurbishment actions being planned in line with the corporate business plan.

We are also implementing a number of heat recovery projects at Cologne and Saarlouis assembly plants, including heat recovery from paint oven exhaust stacks, air recirculation systems, and heat recovery from paint spray booths incorporating heat pump technology. We are also recovering waste heat from the air compressor plant to preheat the paint phosphate tank, and making modifications to plant heating and ventilation systems to establish better air recirculation control and temperature control. Wherever feasible, heat energy recovery will be measured by site building management systems. Through these measurements, we know that the Cologne paint oven exhaust stack system has already returned 7 GW-h since it began operation in October 2013. Heat recovery projects currently underway will deliver around 150 GW-h of energy savings per year from 2015 onward.

We are continuing implementation of a **new parts-washing system** developed in partnership with our supplier, ABB Robotics. Conventional parts-washing systems remove dirt chemically by spraying parts with high volumes of water and detergent at low pressure. Our new standard system, in contrast, cleans parts mechanically by moving them in front of specialized high-pressure nozzles with a robotic arm. This new system represents a significant leap forward in energy efficiency that also improves quality, flexibility, productivity and cost because it uses a smaller pump and lower operating temperatures. We are now using this technology as standard for all engine and transmission final wash applications globally, ensuring that the energy and cost savings will be realized by all future vehicle programs.

Other efforts to improve the energy efficiency of Ford's plant operations include:

- aggressively curtailing energy use during nonproduction periods, including a paint shop emissions abatement equipment shutdown plan at nine North American assembly plants that reduces energy use and related CO_2 emissions by approximately 5,000 tonnes per facility per year;
- installing optimized compressed air machines, which are a significant energy user in manufacturing facilities; and
- installing automated control systems on plant powerhouses and wastewater treatment equipment to increase energy and process efficiency.

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1. Louisville Assembly is excluded from this program because it was not operating in 2011.
2. We calculate plant-level energy intensity slightly differently at different plants, depending on the operations performed there. Depending on the plant, Ford will calculate energy intensity in terms of source energy consumed (in MMBtus) divided by the number of vehicles produced, number of engines, or powertrain components produced. The percent change in energy intensity are tracked for each facility on both a monthly and annual basis. Ford normalizes its plant-level numbers to account for changes in production volume, and heating and cooling degree days. These metrics are rolled up to the corporate level, with a corporate-wide percent improvement in energy intensity calculated by taking a weighted average of the percent change in energy intensity at the individual facilities.

Renewable Energy

Ford is actively involved in the installation, demonstration and development of alternative sources of energy. We also purchase renewable energy indirectly from utilities. Ford used 23,650 kWh of direct (or self-generated) renewable energy and we purchased 936,291 kWh of indirect renewable energy in 2012, which is enough electricity to power seven assembly plants for one year.[1]

Ford's Dagenham Diesel Engine Assembly line in the U.K. was the first automotive plant in the world to obtain all of its electrical energy needs from two on-site wind turbines, which have been in operation since 2004. A third two-megawatt wind turbine was installed in 2011.

A few miles from Dagenham, Ford's Dunton Technical Centre is also powered by electricity from renewable sources. Since March 2009, electric power on the 270-acre site, which is home to a team of approximately 3,000 engineers, has been purchased from 100 percent renewable sources. The majority of the electricity, supplied by GDF, is sourced from a combination of hydro, wind and waste-to-energy generation, and replaces energy from traditional sources that would have produced an estimated 35,000 metric tons of carbon dioxide (CO_2) emissions annually.

Since 2008, we have been sourcing renewable electricity to cover the full electric-power demand of our manufacturing and engineering facilities at our Cologne Plant in Germany. This includes the electricity needed for the assembly of the Ford Fiesta models at the plant. Through this initiative, the Company has reduced its CO_2 emissions by 190,000 metric tons per year. In 2012 a 1 MW photovoltaic installation on the roof of the Ford Customer Service Division warehouse in Merkenich was commissioned contributing further to our renewable-energy efforts.

In Wales, Ford's Bridgend Engine Plant was the first car manufacturing plant in Europe retrofitted with an integrated, grid-connected solar/photovoltaic installation. The system has been in operation since 1998.

In North America, examples of installed renewable-energy technologies include a photovoltaic array and solar thermal collector at the Ford Rouge Visitors Center. The adjacent Dearborn Truck Plant has a "living roof" system, which uses a thick carpet of plants to reduce the need for heating and cooling, while also absorbing rainwater. At the Lima Engine Plant in Lima, Ohio, a geothermal system provides process cooling for plant operations as well as air tempering for employee comfort. This system uses naturally cooled 40° F water from two abandoned limestone quarries located on the plant site. The installation cost was comparable to that of the traditional chiller and cooling tower design that it replaced. This award-winning project eliminates the emission of 4,300 metric tons of CO_2 each year. At our Michigan Assembly Plant we partnered with DTE Energy and the state of Michigan to build a solar photovoltaic array to provide power to the plant and to build an energy storage system to store energy produced by the solar array until it is needed. The energy is stored in a large battery system that in turn recharges electric material-handling vehicles used on-site. These vehicles were converted from diesel engines to electric vehicles to move parts between buildings at the site. The Michigan Assembly Plant also uses methane released from decaying trash at a nearby landfill to heat one of the buildings on-site, which reduces emissions of this potent greenhouse gas. In 2012, we installed a solar-powered trash compactor at our Michigan Proving Grounds in Romeo, Michigan, which compresses waste more efficiently than the previous one. The resulting compacted waste is sent to an incinerator where it is converted into power for local residents. Please see the Waste section for more information on this technology.

In Mexico, Ford's Hermosillo Stamping and Assembly Plant (HSAP) recently signed a contract to begin purchasing solar energy produced from a local solar farm. Beginning in late 2014, HSAP will purchase approximately 8 million kWh per year of solar energy, or about 6 percent of the facility's total energy requirements. The solar energy will reduce indirect CO_2 emissions from the facility by over 4,600 tons of CO_2

per year.

In India, we have been using solar thermal heating at the Chennai plant to heat water for cooking in the main cafeteria since 2011. Using this system, sterilized water is pumped through thermal solar panels and then taken to the cafeteria for cooking at approximately 50° C higher than water that was previously used in cooking boilers. This system has reduced boiler diesel consumption by approximately 420 liters per day. The system is expected to pay for itself in four years.

1. 2013 totals were not available at time of publication but will be included in next year’s report.

Non-CO_2, Facility-Related Emissions

We report on a variety of non-carbon dioxide (CO_2) facility emissions in the Climate Change and the Environment Data section. In this section, we discuss how we are reducing emissions of volatile organic compounds (VOCs) at our facilities. VOCs are a significant aspect of Ford's manufacturing operations due to the size and number of paint shops that we operate.

Since 2000, Ford's North American operations have cut VOC emissions associated with the painting process (by far our largest source of VOC emissions) by 50 percent. In 2013, these operations emitted 16.8 grams of VOCs per square meter of surface coated, down from 18 grams in 2012. Because the control equipment used to reduce VOC emissions consumes significant amounts of energy, we have worked to identify innovative approaches to painting that meet cost, quality and production goals while allowing us to reduce energy use significantly and maintain environmental compliance.

Ford developed a Paint Emissions Concentrator (PEC) technology (formerly referred to as "fumes-to-fuel"), which uses a fluidized bed adsorber and desorber, and condensation equipment to collect and concentrate solvent emissions into liquid form. The intent of the technology is to collect a portion of the VOCs from the spray-booth exhaust, super-concentrate them in the paint emissions concentrator, then condense and store them on-site for use as fuel source. In this way, the solvent emissions are recycled back into the production process and overall VOC emissions are reduced. We are currently using this technology at our Oakville facility. In 2013, the Oakville PEC captured and recycled more than 17,000 gallons of solvent material.

Our PEC technology has the potential to reduce CO_2 emissions by 70 to 80 percent compared to traditional abatement equipment. PEC technology coupled with the recycling of collected solvents also has the potential to eliminate nitrogen oxide emissions compared to conventional abatement approaches, which involve the oxidation of the solvents. There is also the potential to reform the captured VOCs into hydrogen, which could be used as a fuel for fuel cells. We are working with a Canadian university to drive the development of the PEC technology and evaluate the potential for producing and using hydrogen fuel.

We are also continuing to use an innovative new windshield attachment process that reduces VOC emissions. The typical method to attach a windshield – used currently at Ford and throughout the industry – is to first wipe the glass with a solvent cleaner, and then apply a primer and adhesive to secure the windshield to the vehicle. However, this method releases a small amount of highly undesirable solvent emissions. Ford's new patented technology eliminates the use of the solvents that contain VOCs and simplifies the manufacturing process by reducing steps, such as wiping the glass clean. Ford is working with Plasmatreat, an Illinois-based supplier, to implement the technology. The technology will be offered worldwide, first in equipment that Plasmatreat plans to sell or lease to Ford, then to other automakers, the heavy-truck market, the motorhome and bus industries, and other customers who want to use it.

Finally, we are reducing VOC emissions with an innovative paint process called "3-Wet." This process reduces VOC emissions by 10 percent and has other environmental, financial and quality benefits. For more information on 3-Wet, please see the Operational Energy and Greenhouse Gas Emissions section.

Water Use

Water conservation is an integral part of Ford's sustainability strategy. Many vehicle manufacturing processes require water, and water is used at every point in our supply chain. Our water-related risks come not only from being a direct water user, but from being a large purchaser of water-intensive materials, parts and components. Because this issue has increased in importance and focus for Ford in recent years, we now discuss it in its own separate Water section.

Waste Management

Ford's environmental goals include reducing the amount and toxicity of manufacturing-related wastes and ultimately eliminating the disposal of waste in landfills. Manufacturing byproducts include both hazardous and nonhazardous wastes. In 2013, we introduced a new plan to reduce waste sent to landfill by 40 percent on a per vehicle basis between 2011 and 2016 globally. We have already reduced global per vehicle waste to landfill by 40 percent from 2007 to 2011. In 2013, Ford facilities globally sent approximately 49,800 metric tons of waste to landfill, a reduction of 5.4 percent from 2012.

In 2013, Ford facilities globally generated approximately 43,000 metric tons of hazardous waste, which is comparable to our 2012 hazardous waste-generation levels, despite increased vehicle production. We reduced hazardous waste on a per vehicle basis by 7 percent compared to 2012 and by 27 percent over the last five years. Ford has chosen to target eliminating the landfill of hazardous waste first, because this provides the quickest and most cost-effective benefits to human health and the environment.

Ford's five-year global waste-reduction plan details how the company will lessen its environmental impact

5 Key Actions

Invest

- Continue investing in new technologies that minimize waste

Partner

- Partner with suppliers to increase use of eco-friendly packaging

Standardize

- Standardize how waste is tracked and sorted at each point

Enable

- Enable local plants to affect waste management change

Identify

- Identify the five largest volume sources of waste-to-landfill at each facility

Current waste mix

- Wastewater sludge
- Recovered paint solids
- Packaging waste
- Used oils and waste solvent
- Grinding swarf (metallic particles, abrasives and oils)
- Other wastes

Fun fact

The Oakville Assembly Plant in Canada is the first Ford North American vehicle assembly plant to achieve zero waste to landfill status. Joining Windsor Engine Plant and Essex Engine Plant, now all Ford manufacturing operations in Canada send zero waste to landfill.

Progress

Ford cut the amount of waste to landfill generated per vehicle produced globally from 33 pounds in 2009 to 18 pounds in 2013.

Goal

By 2016, Ford will reduce pounds of waste to landfill generated per vehicle globally to 15 pounds.

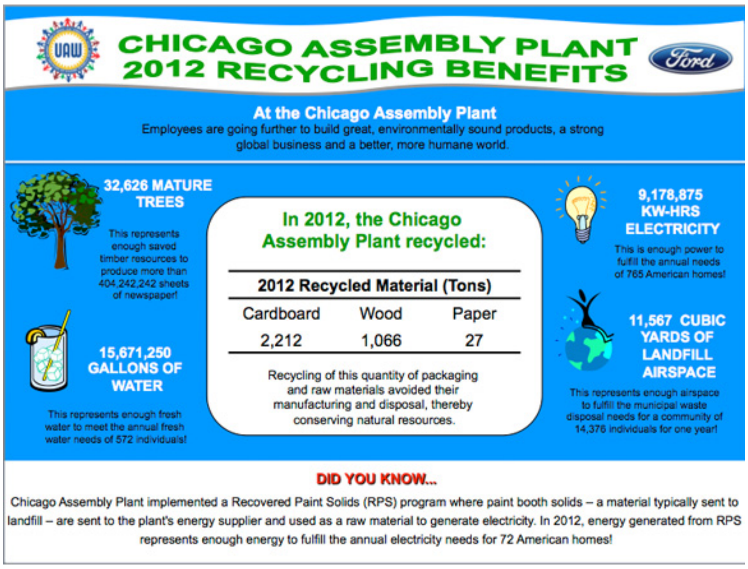
We will reach our new waste-reduction goal and continue to build on our past success in waste reduction through many programs, including:

- Identifying the five largest-volume waste to landfill streams at each plant, developing plans to reduce each and track progress
- Minimizing waste by leveraging the Ford production system – a continuously improving, flexible and disciplined common global production system that encompasses a set of principles and processes to drive lean manufacturing
- Improving waste-sorting procedures to make recycling and reuse easier
- Investing in new technologies that minimize waste, such as dry-machining
- Expanding programs that deal with managing specific kinds of waste, such as metallic particles from the grinding process and paint sludge

The following Ford facilities have achieved Ford's stringent definition of zero waste to landfill[1]:

- JMC Xiaolan
- Chennai Assembly
- Cologne Assembly
- Saarlouis Assembly
- Essex Engine
- Van Dyke Transmission
- Cologne Engine
- Cologne Die Cast
- Cologne Cotarko Forging
- Chennai Engine
- Windsor Engine
- Ford Thailand Manufacturing
- Bordeaux Transmission
- Engine Manufacturing Development Operations/Beech Daly Technical Center
- Michigan Proving Grounds
- Rawsonville
- Oakville Assembly

We are also improving the way we communicate our waste reduction success to employees as part of an effort to engage employees in further waste-reduction improvements. We are reporting not just waste-reduction and recycling totals, but how these numbers translate into more meaningful impacts like number of trees saved. An example of one of these communications is provided below.



Some other successes of our waste-reduction efforts in 2013 include the following:

- We continued to implement our minimum quantity lubricant (MQL) machining process (also called near-dry machining) that reduces waste by more than 80 percent for each engine we produce, also saving oil and water. We have now implemented this process at six plants in North America, Asia, and Europe. For more information on the water benefits of MQL, please see the Water section.
- Our Chennai Vehicle Assembly Plant improved the practices at their hazardous waste storage yard. By using Ford Production System principles to standardize the process, the plant was able to minimize environmental and safety hazards, meanwhile achieving economic benefits from proper waste segregation.
- We initiated efforts to recycle grinding swarf at U.S. and Canadian facilities. This pilot program has the potential to eliminate of 3 million pounds of waste sent to landfill each year.
- Ford of Mexico recycled 33,602 tonnes of aluminum, cardboard, paper, scrap metal, plastics, wood and glass.
- Cuautitlán Stamping and Assembly Plant recently implemented an innovative recycling project aimed at keeping car parts containers out of landfills by restoring them for delivery to various schools where they will be used as trash cans.
- Kentucky Truck Plant started to recycle bailed plastic, Tyvec-coated paper bails and five-gallon pails that were going to landfill. Now 14,500 pounds previously sent to landfill is now being captured for reclamation.
- Sterling Axle Plant began sending one third of their lapping compound, approximately 70,000 kg/year, for reblending in order to make new product for use at the plant instead of landfilling the material.
- Ford Argentina donated more than 4 tons of nonreturnable PET bottles to "Fundación Banco de Bosques" (Forest Bank Foundation) that aims to save native forests which are in danger of extinction.
- Kocaeli Assembly Plant is keeping 500 tonnes/year of municipal waste out of landfills by using it as an alternate fuel in cement kilns.

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1. Waste to landfill is defined as all production waste sent to landfill, excluding episodic waste, and construction and demolition debris. Scrap metal is not included in waste to landfill.

Sustainable Land Use and Biodiversity

Our activities have the potential to affect land use, nature and biodiversity, directly and indirectly. Our real estate portfolio includes properties for manufacturing and office use. The construction and operation of these facilities have direct impacts on land.

Ford's most significant potential impacts on land and biodiversity are indirect, occurring elsewhere in our value chain or arising from the use of our vehicles. Indirect impacts include the extraction of raw materials to make vehicle parts, habitat fragmentation from road construction, localized pollution from vehicles and the potential effects of climate change on biodiversity.

Many of our facilities have taken steps to improve biodiversity and wildlife habitat on their land.

A highly visible example of Ford's commitment to sustainability can be seen on more than 70 acres of Ford-owned land throughout southeast Michigan, which is adorned with sunflowers and native prairie plantings. These plantings provide habitat for wildlife such as white-tailed deer, red fox, wild turkeys and coyote. All of these species have been spotted at Ford World Headquarters, which has about six acres of native prairie. These plantings also reduce mowing and fertilization costs. By replacing what otherwise would be traditional turf grass, the company saves approximately 30 percent on the costs of labor, gas and fertilizer. We also use native plants in our landscaping whenever possible, as they are better adapted to local conditions, and provide food and shelter for wildlife.

We continue to recycle our landscaping debris as compost in Ford-owned farm fields throughout southeast Michigan. By allowing our leaves, grass and plant clippings to collect and decompose throughout the summer, we are able to add more than 3,000 cubic yards of nutrient-rich compost to our fields in lieu of a synthetic, petroleum-based fertilizer each year.

We are also installing "smart" irrigation systems at some of our Dearborn (Michigan) properties. These systems use site conditions – such as soil and plant types, evapotranspiration rates and local weather data – to program watering only when it is needed. To date, systems at 49 sites have been completed and are providing water savings of just over 30 percent. Systems at the remaining five sites in our commercial property portfolio will be completed this year.

We are also reducing emissions produced in normal lawn maintenance by using propane-fueled mowers, which produce approximately 24 percent fewer greenhouse gas emissions, 20 percent fewer nitrogen oxide emissions, and 60 percent less carbon monoxide than gasoline-powered mowers. Propane also eliminates fuel spills that often occur during the refueling of traditional gas mowers, and propane is nontoxic and soluble in water. In addition to these environmental benefits, the vast majority of propane is domestically produced and it is less expensive than gasoline. Propane also increases mower engine life and reduces maintenance because it burns cleaner than gasoline, which further reduces maintenance costs and resource use. Fairlane Grounds, which provides lawn mowing services at Ford facilities in the Dearborn area, has already converted 10 mowers (or about a quarter of their mower fleet) to run on propane instead of gasoline. All future scheduled mower replacements will be propane mowers, until the entire fleet is propane-powered. In addition, Fairlane Grounds has piloted tested Ford F-350 trucks converted to run on propane by Roush CleanTech and is considering replacing a portion of its vehicle fleet with propane autogas-fueled units. An on-site propane fueling station for trucks and mowers has been installed.

Green Buildings

Ford is a leader in green building and is committed to the sustainable design of our facilities and landscapes using the basic principles of resource effectiveness, life cycle assessment, health, safety and environmental performance. In the past, we have included green building design principles into our buildings on a case-by-case basis. To help standardize and broaden our efforts in this area, we are currently developing corporate specifications for building new facilities that will focus on sustainability. These specifications require that new manufacturing facilities be designed and constructed using the best practices Ford has developed at plants all over the world. These standards will act to replicate best practices across our global operations, and create efficient and sustainable plants. We are coordinating this effort through our Global Facilities Forum, described in the Facilitating and Measuring Progress section. Some examples of best engineering practices that may be implemented in our new facilities include:

- Advanced water-treatment technologies, to allow the reuse of water and reduce water-supply requirements, water discharges, use of treatment chemicals and the generation of solid waste;
- Energy-saving technologies, such as advanced control of air compressors, high-efficiency lights, variable-drive electric motors, skylights and daylighting, and white roofing materials; and
- Advanced paint shop technologies, to reduce emissions, energy use and waste, including wet- on-wet paint and advanced automated paint application equipment.

Ford is a member of the U.S. Green Building Council (USGBC) and a supporter of its green building rating system, known as LEED® (Leadership in Energy and Environmental Design). The LEED system includes a series of standards used for certifying buildings as Silver, Gold or Platinum, and it is recognized as the industry standard for green building. Ford employees who are involved in the design, operation and maintenance of commercial and manufacturing facilities have obtained LEED Accredited Professional certification, which demonstrates their proficiency in the application of the LEED rating systems. Having this expertise in-house will continue to strengthen our knowledge and the speed at which we apply environmentally sustainable technologies and processes at our facilities.

Ford is evaluating existing buildings to achieve LEED certification. The LEED v3 Green Buildings, Operations and Maintenance rating system, or LEED GBOM, helps building operators measure operations, improvements and maintenance on a consistent scale, with the goal of maximizing operational efficiency while minimizing environmental impacts. The standards are intended to promote healthy and environmentally friendly buildings that are also durable, affordable and high-performing by focusing on six key areas: sustainable site management, water efficiency, energy and atmosphere impacts, materials and resource use, indoor environmental quality and innovations in operations.

Ford piloted the LEED Existing Building (LEED-EB) certification process on Corporate Crossings, an office building that Ford developed in 1999 in Dearborn, Michigan. In 2011 we achieved LEED-EB Silver Certification for this building, the first Ford Motor Company building certified under the LEED-EB program. We are now in the process of seeking LEED Existing Buildings: Operations and Maintenance (LEED-EBOM) certification for our Research and Innovation Center (RIC) in Dearborn. In March 2013, RIC entered the “performance period” of the certification process. During this period, actual building performance is measured for at least three months, after all of the changes we are making to the building and its operation to obtain certification credits are implemented. These changes include energy-efficiency technology upgrades, operational policies and staff training. We hope to have the RIC facility

LEED-EBOM certified in 2014.

Based on these experiences, Ford is planning to seek certification of the balance of our portfolio of commercial office buildings through the USGBC's LEED for Existing Buildings: Operations and Maintenance Volume Program. We are initially working to certify 25 buildings in Dearborn, Michigan, through this program. We hope to complete this certification process in 2015. The LEED Volume Program was designed by the USGBC to meet industry needs for a streamlined approach to certifying similar buildings and spaces. The program, through the use of prototype standards, allows organizations to simplify the LEED documentation for multiple buildings or spaces of a similar type or management.

Our goal is to assure that the green building practices, procedures, policies and initiatives we have already developed will meet USGBC LEED-EB standards and help create a comprehensive sustainability program for our portfolio of commercial office buildings.

Ford is also working to advance green building practices through partnerships with our building-related service providers. These partnerships help to educate service providers and provide a forum to exchange information on the concepts of sustainable design. For example, we have held training sessions on site selection, water efficiency, energy-use reductions, sustainable materials and resources, and indoor environmental quality.

We are also working with our dealers to help them improve the environmental performance of their facilities. For more information on our work to help "green" Ford and Lincoln dealerships, please see below and the Dealers section.

Some examples of Ford's green building projects include:

Ford World Headquarters Green Roof – Dearborn, Michigan

In 2012, we refurbished a portion of the roof on our corporate world headquarters building in Dearborn, Michigan. As part of this effort, we installed 5,000 square feet of green roof on the building. This "living roof," which is made from multiple varieties of sedum plants, helps to reduce stormwater runoff from the building.

Ford World Headquarters Green Roof – Dearborn, Michigan

Green Dealership – Dagenham Motors, Barking, United Kingdom

Ford's Dagenham Motors dealership in Barking, England, recently built an all-new "green" dealership using the latest environmentally friendly materials and a number of sustainable and energy-saving features. The facility includes new and used car showrooms and a service center.

Water use at the facility is reduced by capturing rainwater runoff from the roof and storing it in a 3,500-gallon underground tank that supplies water for washing cars and flushing toilets. The rainwater-harvesting tank includes a UV sterilization unit, and inline contaminate and particulate filters that enable the water to be suitable and hygienic for hand washing. In addition, waste oil from cars that have been serviced is reused for heating the premises by fueling an integrated used-oil burner on the site. In addition, a wind turbine was installed to generate up to 10 percent of the site's electricity, and the facility used green construction practices. Approximately 1,800 square meters of non-hazardous soil that was excavated from the site during construction will be reused to landscape the site rather than being transported to landfill.

Green Housekeeping Program

Ford promotes the use of environmentally friendly products in the operation and maintenance of its facilities. One example of this is the continued expansion of our "green housekeeping" program. Through this program, we are working with our Tier 1 suppliers and contractors to promote the use of environmentally friendly cleaning practices and water-based products that help to reduce the impact of facility operations on the environment. Our cleaning service providers use highly concentrated, water-based chemicals with more efficient packaging, which significantly reduces product waste and the amount of fuel required to ship products. These green housekeeping practices are now in use throughout our North American manufacturing locations and commercial office buildings.

Ford Rouge Center

Ford's largest green-building initiative was the redevelopment of the 600-acre Ford Rouge Center in Dearborn, Michigan, into a state-of-the-art lean, flexible and sustainable manufacturing center. The focal point of the center, the Dearborn Truck Plant, boasts a 10.4-acre living roof, part of an extensive stormwater management system that includes bioswales and porous pavement to slow and cleanse the water. The Dearborn Truck Plant also features abundant skylights to maximize daylight in the facility. And, the Rouge Center features 100 acres of sustainable landscaping to help restore soils and support wildlife habitat.

Corporate Crossing (LEED-EB)

In 2011 we achieved LEED Existing Building certification for our Corporate Crossing office building, located in Dearborn, Michigan. This is the first Ford facility to achieve this LEED rating.

Rouge Visitor Center (LEED-Gold)

The redeveloped Ford Rouge Center includes the LEED-Gold certified Rouge Visitor Center, a 30,000-square-foot facility featuring two multiscreen theaters and an observation deck. The facility captures rainwater for plumbing and irrigation, and uses photovoltaic-solar panels to produce energy. In addition, "green screens" of shading vines cover some parts of the building to reduce energy use.

Fairlane Green (LEED-Gold)

Ford has developed a 1-million-square-foot green retail center on its 243-acre industrial waste landfill in Allen Park, Michigan, earning the national Phoenix Award for excellence in brownfield development. In addition, Fairlane Green Phase I received the nation's first LEED-Gold certification for a core and shell retail development, for its use of retention ponds for irrigation, sustainable landscaping and white roofs, and for the preservation of natural areas. The buildings feature high-efficiency heating and cooling systems, added insulation and weather sealing, and efficient windows and doors.

Product Review Center (LEED-Silver)

Ford's Product Review Center in Dearborn showcases Ford's latest products and green building principles. The LEED-Silver-certified building incorporates an innovative system to recycle water for irrigation and cooling, large windows to maximize daylight and extensive use of local and recycled materials.

Compliance

Manufacturing Plants Notices of Violation

Ford received four notices of violation (NOVs) from government agencies in 2013: one in the U.S., one in Brazil, one in South Africa and one in Australia. The issuance of an NOV is an allegation of noncompliance with anything from a minor paperwork requirement to a permit limit, and does not mean that the company was noncompliant or received a penalty.

Off-Site Spills

In 2013, no off-site spills occurred at Ford manufacturing facilities.

Fines and Penalties Paid

In 2013, Ford paid no fines or penalties globally pertaining to environmental matters in our facilities.

Remediation

Ringwood Mines Landfill Site

Ford Motor Company continues to address concerns raised in connection with Ford's prior disposal activities in Ringwood, New Jersey. Ford, with the Borough of Ringwood's cooperation, has completed the necessary reports for the three soil operation units (OUs). It is anticipated that the U.S. Environmental Protection Agency will select a final remedial approach and issue a Record of Decision (ROD) for the three soil OUs later this year. Remedy construction could begin in early 2015. The groundwater OU will be addressed in a future Record of Decision.

Data

Fuel Economy and CO_2 Emissions

- Ford U.S. Corporate Average Fuel Economy
- Ford U.S. CO_2 Tailpipe Emissions per Vehicle (Combined Car and Truck Fleet Average CO_2 Emissions)
- Ford Europe CO_2 Tailpipe Emissions per Passenger Vehicle
- Ford Europe CO_2 Tailpipe Emissions per Light Commercial Vehicle
- Ford Switzerland CO_2 Tailpipe Emissions per Passenger Vehicle

Tailpipe Emissions

- Ford U.S. Average NOx Emissions
- Ford U.S. Average NMOG Emissions
- Ford U.S. Average Vehicle Emissions

Operational Energy Use and CO_2 Emissions

- Worldwide Facility Energy Consumption
- Worldwide Facility Energy Consumption per Vehicle
- Worldwide Facility CO_2 Emissions
- Worldwide Facility CO_2 Emissions per Vehicle
- Energy Efficiency Index

Emissions (VOC and Other)

- North America Volatile Organic Compounds Released by Assembly Facilities
- Ford U.S. TRI Releases
- Ford U.S. TRI Releases per Vehicle
- Ford Canada NPRI Releases
- Ford Canada NPRI Releases per Vehicle
- Australia National Pollutant Inventory Releases (Total Air Emissions)

Waste

- Regional Waste to Landfill
- Waste to Landfill per Vehicle
- Regional Hazardous Waste Generation
- Hazardous Waste Generation per Vehicle

Data: Fuel Economy and CO_2 Emissions

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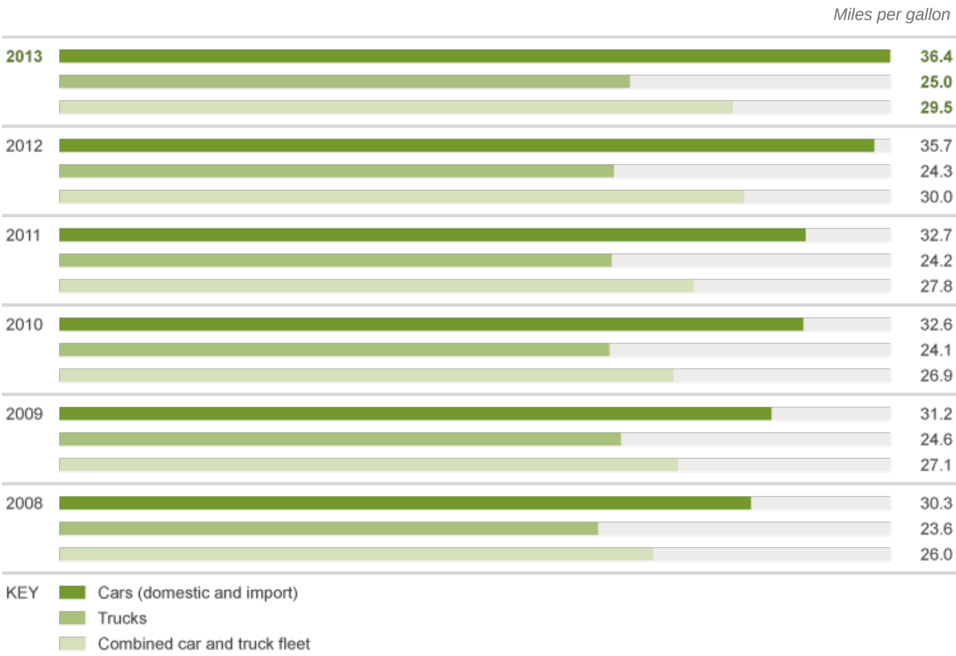
A. Ford U.S. Corporate Average Fuel Economy



	2008	2009	2010	2011	2012	2013
Cars (domestic and import)	30.3	31.2	32.6	32.7	35.7	**36.4**
Trucks	23.6	24.6	24.1	24.2	24.3	**25.0**
Combined car and truck fleet	26.0	27.1	26.9	27.8	30.0	**29.5**

Third party rating

Data notes and analysis

In 2013, we improved the average fuel economy of our car fleet by 2 percent, and of our truck fleet by 3 percent compared to 2012. However, our combined corporate average fuel economy declined by 1.7 percent in 2013 due to increased customer demand for trucks over cars.

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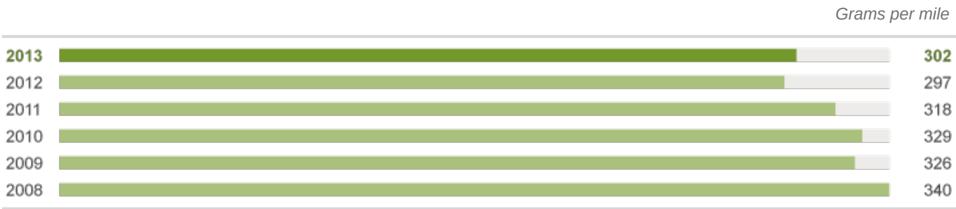
B. Ford U.S. CO_2 Tailpipe Emissions per Vehicle (Combined Car and Truck Fleet Average CO_2 Emissions)



	2008	2009	2010	2011	2012	2013
	340	326	329	318	297	**302**

Data notes and analysis

Improvement is reflected in decreasing grams per mile. This is the second year that the CO_2 data has come directly from Ford's official Greenhouse Gas report. Under the One National Program regulation, 2012 MY is the first year where a separate greenhouse gas compliance report is required, in addition to the annual CAFE report. The CO_2 value includes FFV credits, but does not include credits/debits for air conditioning or off-cycle technologies or CH_4/N_2O compliance.

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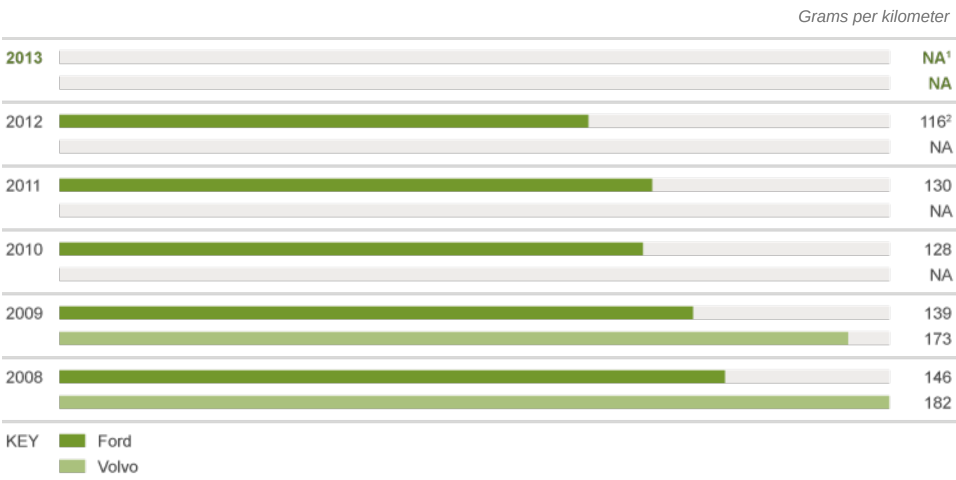
C. Ford Europe CO_2 Tailpipe Emissions per Passenger Vehicle



	2008	2009	2010	2011	2012	2013
Ford	146	139	128	130	116[2]	**NA[1]**
Volvo	182	173	NA	NA	NA	**NA**

Data notes and analysis

1. No data are yet available for 2013. Official 2013 data will be published by the European Commission in the fourth quarter of 2014.
2. For 2012, final official data from the European Commission (EC) were published in November 2013 for passenger cars (vehicle category M1). For passenger cars, only 65 percent of the best-CO_2-performing fleet vehicles is accounted in this data as part of the EC's phase-in plan. Improvement is reflected in decreasing grams per kilometer. These figures are based on production data for European markets. European and U.S. fleet CO_2 emissions are not directly comparable because they are calculated in different units and because they are assessed based on different drive cycles. In 2009, we switched from reporting European vehicle CO_2 emissions as a percent of a 1995 base to reporting actual fleet average CO_2 emissions, to parallel our reporting for other regions.

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D. Ford Europe CO_2 Tailpipe Emissions per Light Commercial Vehicle

Grams per kilometer

	2012	2013
	175[2]	NA[1]

Data notes and analysis

1. No data are yet available for 2013. Official 2013 data will be published by the European Commission in the fourth quarter of 2014.
2. For 2012, final official data from the European Commission (EC) were published in November 2013 for light commercial vehicles (vehicle category N1). For 2012, 70 percent of the best-CO_2-performing light commercial vehicles are accounted for in this data. Note: For EC/Member State 2012 data it is evident that certain data were missing or manifestly incorrect. As a consequence, the 2012 data for light commercial vehicles should be considered incomplete. In 2014, official CO_2 monitoring will begin for light commercial vehicles (category N1). Between 2014 to 2017, the EC “phase-in rule” will be applied by increasing the fleet coverage accounted for in official fleet CO_2 data, starting with 70 percent of the lowest-CO_2 vehicles in 2014, and expanding to 75 percent in 2015 and 80 percent in 2016.

Improvement is reflected in decreasing grams per kilometer. These figures are based on production data for European markets. European and U.S. fleet CO_2 emissions are not directly comparable because they are calculated in different units and because they are assessed based on different drive cycles. In 2009, we switched from reporting European vehicle CO_2 emissions as a percent of a 1995 base to reporting actual fleet average CO_2 emissions, to parallel our reporting for other regions.

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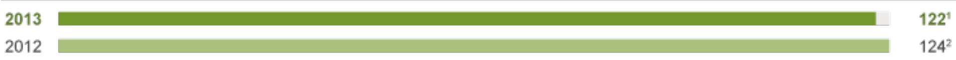
E. Ford Switzerland CO_2 Tailpipe Emissions per Passenger Vehicle

Grams per kilometer



	2012	2013
	124[2]	122[1]

Data notes and analysis

1. Preliminary 2013 data has been published. The 2013 data includes 75 percent of the best-CO_2-performing fleet vehicles, as part of the Swiss phase-in plan.
2. In 2012, Switzerland introduced CO_2 monitoring using the same test methodology applied in Europe with stringent target line. The 2012 data only includes CO_2 monitoring for the second half of the year (Q3 & Q4). The 2012 data includes 65 percent of the best-CO_2-performing fleet vehicles, as part of the Swiss phase-in plan.

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- Greening Our Operations
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  - Tailpipe Emissions
  - Operational Energy Use and CO_2 Emissions
  - Emissions (VOC and Other)
  - Waste
- Case Study: Ford Fleet Purchase Planner
- Voice: John Fleming

Data: Tailpipe Emissions

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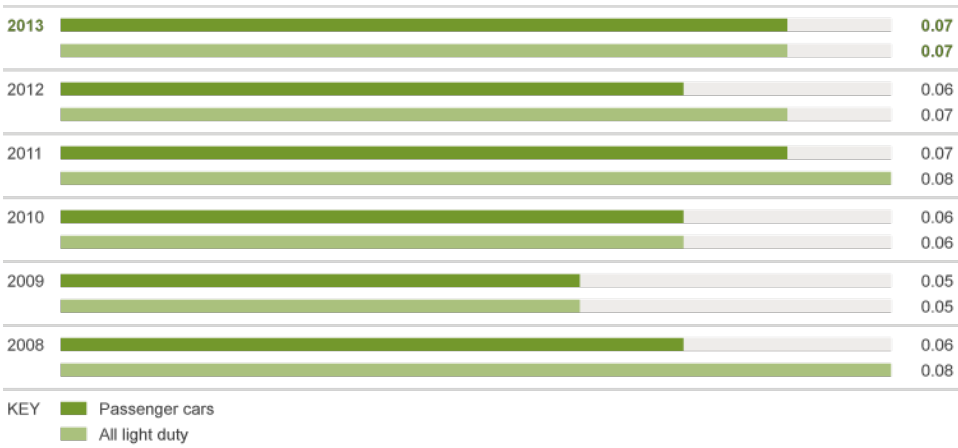
A. Ford U.S. Average NOx Emissions

Grams per mile



	2008	2009	2010	2011	2012	2013
Passenger cars	0.06	0.05	0.06	0.07	0.06	0.07
All light duty	0.08	0.05	0.06	0.08	0.07	0.07

Reported to regulatory authorities (EPA)

Related links

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Non-CO_2 Tailpipe Emissions

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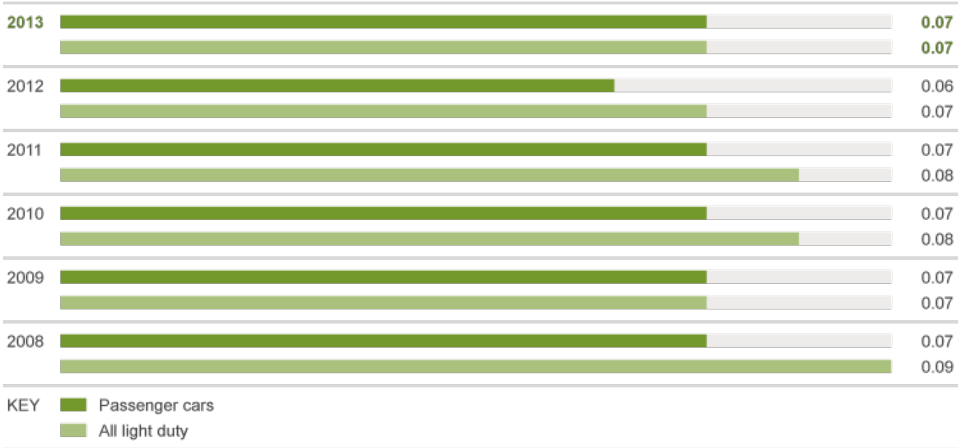
B. Ford U.S. Average NMOG Emissions

Grams per mile



	2008	2009	2010	2011	2012	2013
Passenger cars	0.07	0.07	0.07	0.07	0.06	**0.07**
All light duty	0.09	0.07	0.08	0.08	0.07	**0.07**

Reported to regulatory authorities (EPA)

Data notes and analysis

NMOG = Non-Methane Organic Gases

Related links

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→ Non-CO_2 Tailpipe Emissions

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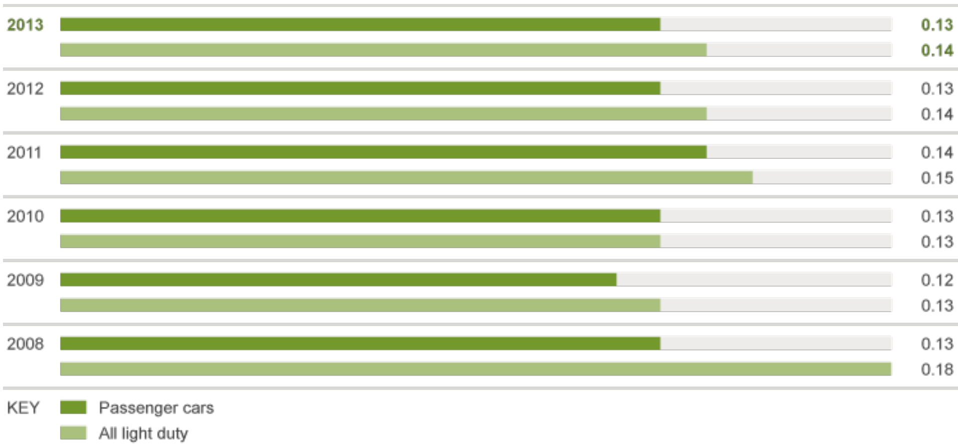
C. Ford U.S. Average Vehicle Emissions

Grams per mile



	2008	2009	2010	2011	2012	2013
Passenger cars	0.13	0.12	0.13	0.14	0.13	**0.13**
All light duty	0.18	0.13	0.13	0.15	0.14	**0.14**

Reported to regulatory authorities (EPA)

Data notes and analysis

Average vehicle emissions are the smog-forming pollutants from vehicle tailpipes, characterized as the sum of [(NMOG + NOx emissions) x volume] for all products in the fleet.

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→ Non-CO_2 Tailpipe Emissions

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Waste
Case Study: Ford Fleet Purchase Planner
Voice: John Fleming

Data: Operational Energy Use and CO_2 Emissions

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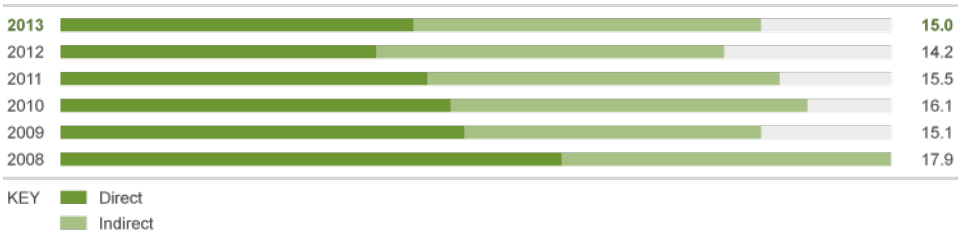
A. Worldwide Facility Energy Consumption



	2008	2009	2010	2011	2012	2013
Direct	10.8	8.7	8.4	7.9	6.8	7.6
Indirect	7.1	6.4	7.7	7.6	7.5	7.5
Total	**17.9**	**15.1**	**16.1**	**15.5**	**14.2**	**15.0**

Data managed through the Global Emissions Manager database

Data notes and analysis

Worldwide facility energy consumption increased from 2012 to 2013 due to increased production, use of additional facilities, and colder weather, which increased heating and cooling-related energy requirements. 2012 data was revised and restated to correct calculation errors.

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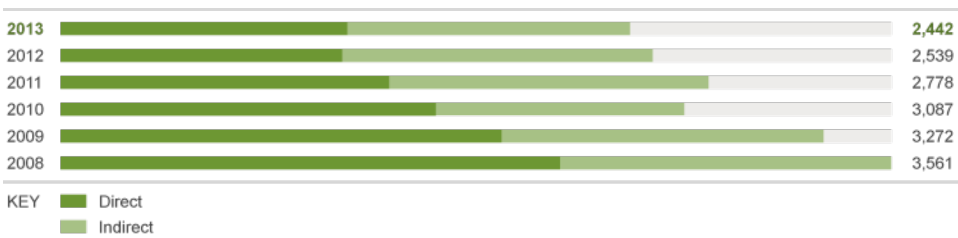
B. Worldwide Facility Energy Consumption per Vehicle



	2008	2009	2010	2011	2012	2013

Direct	2,142	1,891	1,609	1,408	1,207	1,229
Indirect	1,419	1,381	1,478	1,370	1,332	1,213
Total	**3,561**	**3,272**	**3,087**	**2,778**	**2,539**	**2,442**

Data managed through the Global Emissions Manager database

Data notes and analysis

Worldwide facility energy consumption per vehicle produced decreased by 4 percent from 2012 to 2013, reflecting the greater efficiency of our production.

2012 data was revised and restated due to calculation errors.

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C. Worldwide Facility CO_2 Emissions

Million metric tons

	2008	2009	2010	2011	2012	2013
Direct	1.9	1.5	1.7	1.6	1.4	1.5
Indirect	3.5	3.1	3.6	3.5	3.4	3.3
Total	**5.4**	**4.6**	**5.2**	**5.1**	**4.8**	**4.8**

Third party verified (North America and EU)[1]

Reported to regulatory authorities (EU). Voluntarily reported to emissions registries or other authorities in Argentina, Australia, Brazil, Canada, China, the Philippines, Taiwan and the U.S.

Data notes and analysis

Worldwide facilities CO_2 emissions increased by 0.6% from 2012 to 2013 due to increased production. While our CO_2 emissions are linked to the amount of energy we use, and our energy and CO_2 emissions do move in the same direction, they do not necessarily increase or decrease by exactly the same amount. For example, in 2013, our total energy use increased by 6 percent compared to 2012, while our total CO_2 emissions increased by only 0.6 percent.

For 2013, national electricity factors were updated in accordance with internationally published GHG reporting protocols. 2012 data was revised to correct for calculation errors in total direct CO_2 emissions.

1. Sixty-one percent of Ford's global facility GHG emissions are third-party verified. All of Ford's North American GHG emissions data since 1998 are externally verified by The Financial Industry Regulatory Authority, the auditors of the NASDAQ stock exchange, as part of membership in the Chicago Climate Exchange. In addition, all of our European facilities impacted by the mandatory EU Trading Scheme are third-party verified.

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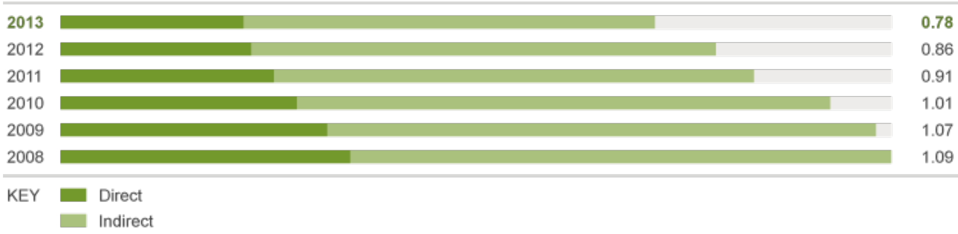
D. Worldwide Facility CO_2 Emissions per Vehicle

Metric tons per vehicle



	2008	2009	2010	2011	2012	2013
Direct	0.38	0.35	0.31	0.28	0.25	**0.24**
Indirect	0.71	0.72	0.70	0.63	0.61	**0.54**
Total	**1.09**	**1.07**	**1.01**	**0.91**	**0.86**	**0.78**

Data managed through the Global Emissions Manager database

Data notes and analysis

CO_2 emissions per vehicle declined for the fifth year, reflecting our focus on improving the energy efficiency of our operations. We are working to meet our goal of reducing global facility CO_2 emissions per vehicle by 30 percent by 2025 from a 2010 baseline. While our CO_2 emissions are linked to the amount of energy we use, and our energy and CO_2 emissions do move in the same direction, they do not necessarily increase or decrease by exactly the same amount. For example, in 2013, our total facilities energy use increased by 6 percent compared to 2012, while our total facilities CO_2 emissions increased by only 0.6 percent. For 2013, national electricity factors were updated in accordance with internationally published GHG reporting protocols. 2012 data was revised and restated to correct for calculation errors in total direct CO_2 emissions and the removal of Geelong Casting and Engine from the vehicle production number.

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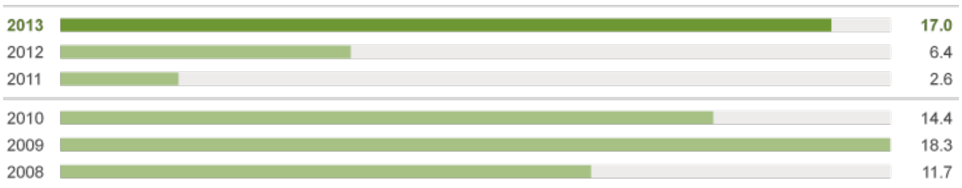
E. Energy Efficiency Index

Percent



2008	2009	2010	2011	2012	2013
11.7	18.3	14.4	2.6	6.4	**17.0**

Data notes and analysis

The energy efficiency index is a normalized indicator of energy used in our manufacturing facilities per vehicle produced based on a calculation that adjusts for typical variances in weather and vehicle production. The Index is set at 100 for the baseline year to simplify tracking annual improvements. In 2012, we expanded our energy efficiency to include global energy use data. In previous years, it only included energy use at North American facilities. In 2012, we also reset the baseline year to 2011. A year 2000 baseline was used through 2006; the baseline was reset to year 2010 starting in 2011. The year 2012 improvement indexed against the year 2011 baseline was 6.4, indicating a 6.4 percent improvement in global energy efficiency per vehicle from 2011 to 2012. Higher percentage reflects improvement. The year 2013 improvement indexed against the year 2011 baseline was 17 (%).

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Data: Emissions (VOC and Other)

Data on this page

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A. North America Volatile Organic Compounds Released by Assembly Facilities

Grams per square meter of surface coated

2008	2009	2010	2011	2012	2013
24.0	21.0	21.6	20.4	18.0	16.8

Data managed through the Global Emissions Manager database

Data notes and analysis

VOC emissions in North America decreased by 6.7 percent between 2012 and 2013; we continue to exceed our goal of maintaining emissions at 24 grams per square meter of surface coated. We achieved this goal through, among other things, the use of mold-in-color plastics (which preclude the need for painting) and our fumes-to-fuel technology, which captures VOC emissions from our paint shops and uses them as an energy source.

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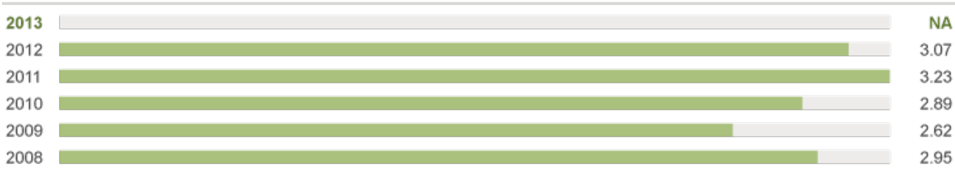
B. Ford U.S. TRI Releases

Million pounds



2008	2009	2010	2011	2012	2013
2.95	2.62	2.89	3.23	3.07	NA

Reported to regulatory authorities (EPA)

Data notes and analysis

Releases reported under the U.S. Toxics Release Inventory (TRI) are all in accordance with the law, and many of them are subject to permits. The data shown are the most recent reported to authorities.

Our U.S. TRI releases decreased from 2011 to 2012, reflecting the benefits of material and process changes. Though our U.S. TRI did increase from 2010 to 2011, due to an increase in production, our U.S. TRI releases per vehicle has decreased consistently each year, reflecting more efficient production.

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C. Ford U.S. TRI Releases per Vehicle

Pounds per vehicle

2008	2009	2010	2011	2012	2013
2.06	2.00	1.80	1.76	1.44	NA

Data notes and analysis

Our U.S. Toxic Release Inventory releases per vehicle decreased from 2011 to 2012, the seventh year in a row we have reduced these emissions. These reductions were achieved through material and process changes.

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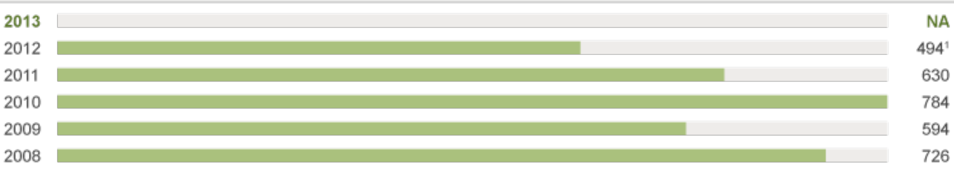
D. Ford Canada NPRI Releases

Metric tonnes



2008	2009	2010	2011	2012	2013
726	594	784	630	494[1]	NA

Reported to regulatory authorities (Environment Canada)

Data notes and analysis

Releases reported under the Canadian National Pollutant Release Inventory are all in accordance with the law, and many of them are subject to permits. The data shown are the most recent reported to authorities.

Our Canada National Pollutant Release Inventory releases decreased from 2011 to 2012. These reductions were achieved through material and process changes.

1. This figure was restated for our 2011-12 report due to an arithmetic error.

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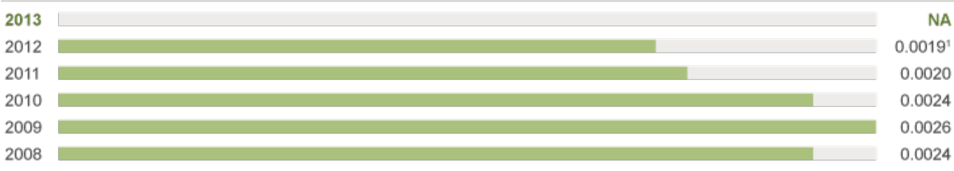
E. Ford Canada NPRI Releases per Vehicle

Metric tonnes per vehicle



2008	2009	2010	2011	2012	2013
0.0024	0.0026	0.0024	0.0020	0.0019[1]	NA

Data notes and analysis

The change in total NPRI releases (see above) resulted in the change in per vehicle releases. Releases reported under the Canadian National Pollutant Release Inventory are all in accordance with the law, and many of them are subject to permits. The data shown are the most recent reported to authorities.

Our Canada National Pollutant Release Inventory releases per vehicle continued to decrease from 2011 to 2012. These reductions were achieved through material and process changes.

1. This figure was restated for our 2011-12 report due to an arithmetic error.

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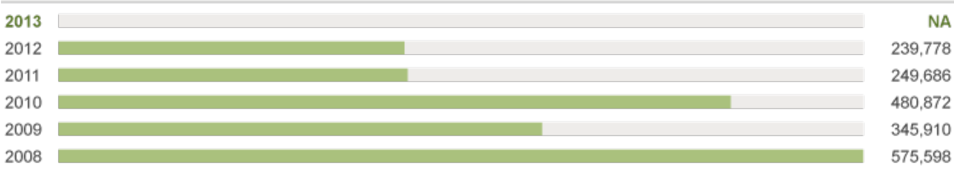
F. Australia National Pollutant Inventory Releases (Total Air Emissions)

Kilograms per year



2008	2009	2010	2011	2012	2013
575,598	345,910	480,872	249,686	239,778	NA

Reported to regulatory authorities (NPI)

Data notes and analysis

Releases reported under the Australian National Pollutant Inventory are all in accordance with the law, and many of them are subject to permits. The data shown are the most recent reported to authorities.

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Data: Waste

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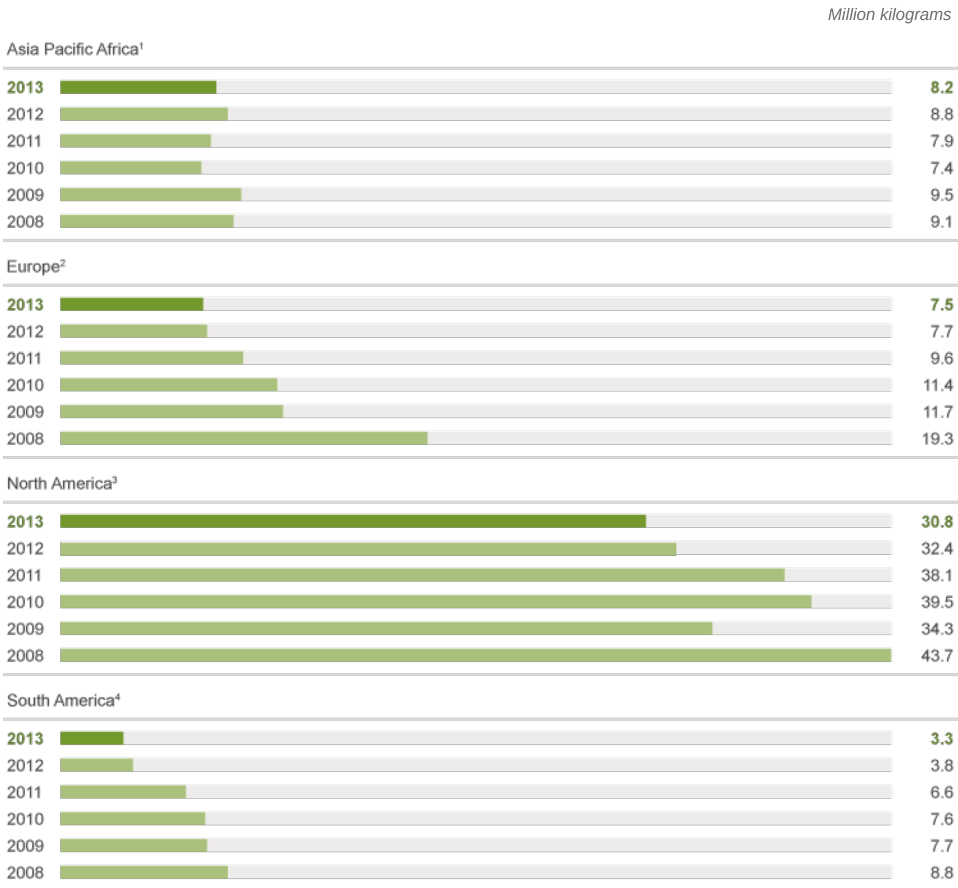
A. Regional Waste to Landfill



	2008	2009	2010	2011	2012	2013
Asia Pacific Africa[1]	9.1	9.5	7.4	7.9	8.8	**8.2**
Europe[2]	19.3	11.7	11.4	9.6	7.7	**7.5**
North America[3]	43.7	34.3	39.5	38.1	32.4	**30.8**
South America[4]	8.8	7.7	7.6	6.6	3.8	**3.3**

Data managed through the Global Emissions Manager database

Data notes and analysis

1. In 2012, waste to landfill was restated for 2011 to correct for misclassifications in disposal and recycling codes. In 2011, waste-to-landfill data was restated for years 2007–2011 because casting sands (a type of waste) associated with the

Geelong foundry (located in the Asia Pacific region) have been removed from the waste-to-landfill totals.

2. In 2012, waste to landfill was restated for 2011 to correct for misclassifications in disposal and recycling codes.
3. In 2012, waste to landfill was restated for 2010 and 2011 to correct for misclassifications in disposal and recycling codes. AutoAlliance International, our joint-venture plant in Flat Rock, Michigan that produces the Ford Mustang, is included beginning in 2009.
4. In 2012, waste to landfill was restated for 2011 to correct for misclassifications in disposal and recycling codes.

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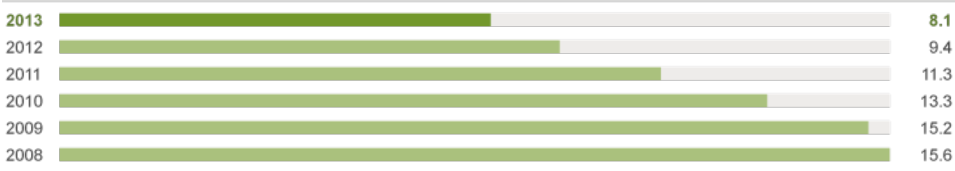
B. Waste to Landfill per Vehicle

Kilograms



2008	2009	2010	2011	2012	2013
15.6	15.2	13.3	11.3	9.4	**8.1**

Data managed through the Global Emissions Manager database

Data notes and analysis

In 2012, waste to landfill per vehicle data was restated for 2010 and 2011 to correct for misclassifications in disposal and recycling codes.

In 2011, waste-to-landfill per vehicle data was restated for all years because casting sands (a type of waste) associated with Geelong foundry (located in the Asia Pacific region) and Taubate foundry (located in the South America region) have been removed from the waste-to-landfill totals for years 2007–2011.

AutoAlliance International, our joint-venture plant in Flat Rock, Michigan, which produces the Ford Mustang, is included beginning in 2009.

In 2013, we reduced waste to landfill on a per-vehicle basis by about 5.4 percent compared to 2012, which reflects our focus on reducing waste produced per unit of production. We decreased waste to landfill primarily through aggressive efforts to generate less waste and recycle more, and through the use of waste-to-energy incineration facilities.

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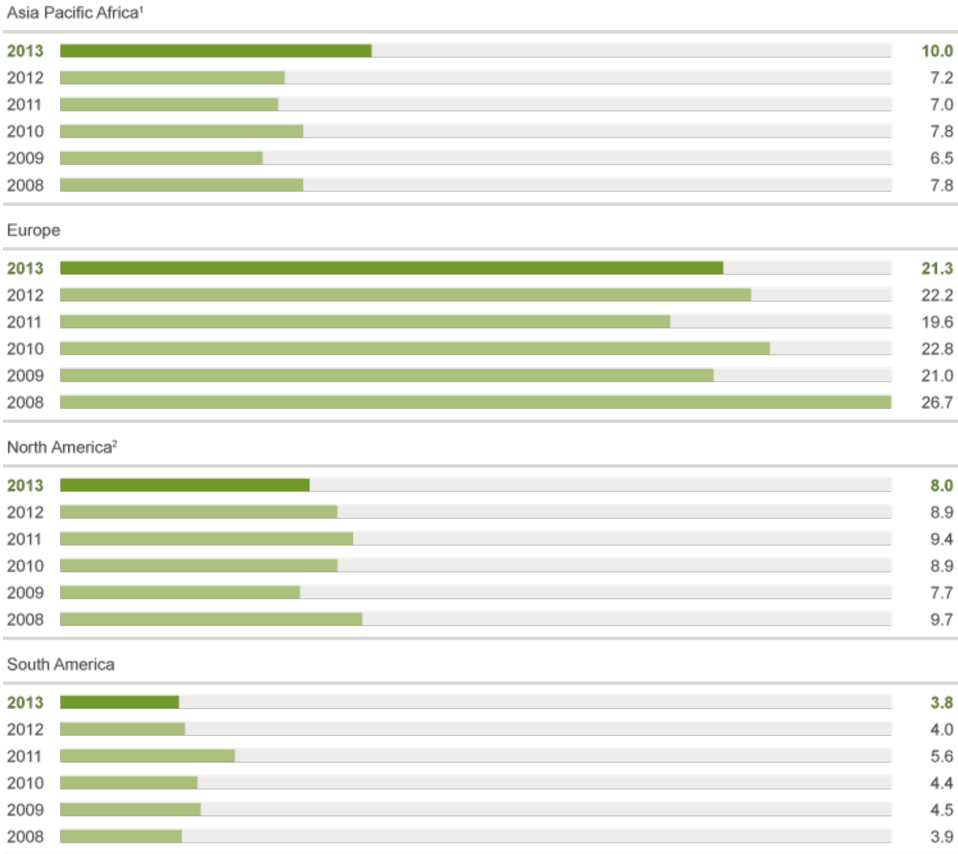
C. Regional Hazardous Waste Generation

Million kilograms



	2008	2009	2010	2011	2012	2013
Asia Pacific Africa[1]	7.8	6.5	7.8	7.0	7.2	**10.0**
Europe	26.7	21.0	22.8	19.6	22.2	**21.3**
North America[2]	9.7	7.7	8.9	9.4	8.9	**8.0**
South America	3.9	4.5	4.4	5.6	4.0	**3.8**

Data managed through the Global Emissions Manager database

Data notes and analysis

1. In 2012, regional hazardous waste in Asia Pacific Africa for 2008, 2009, and 2010 was updated to reflect adjusted production.
2. In 2012, regional hazardous waste in North America was restated for 2011 to correct for misclassifications in disposal and recycling codes.

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D. Hazardous Waste Generation per Vehicle

Kilograms

2008	2009	2010	2011	2012	2013
9.3	9.6	8.8	8.3	7.5	**7.0**

Data managed through the Global Emissions Manager database

Data notes and analysis

In 2012, hazardous waste per vehicle data was restated for 2011 to correct for misclassifications in disposal and recycling codes.

In 2011, hazardous waste to landfill data for 2010 and 2009 was restated due to corrections in the data.

We reduced hazardous waste on a per-vehicle basis by 7 percent compared to 2012 and by 27 percent over the last five years. Ford has chosen to target eliminating the landfill of hazardous waste first, because this provides the quickest and most cost-effective benefits to human health and the environment.

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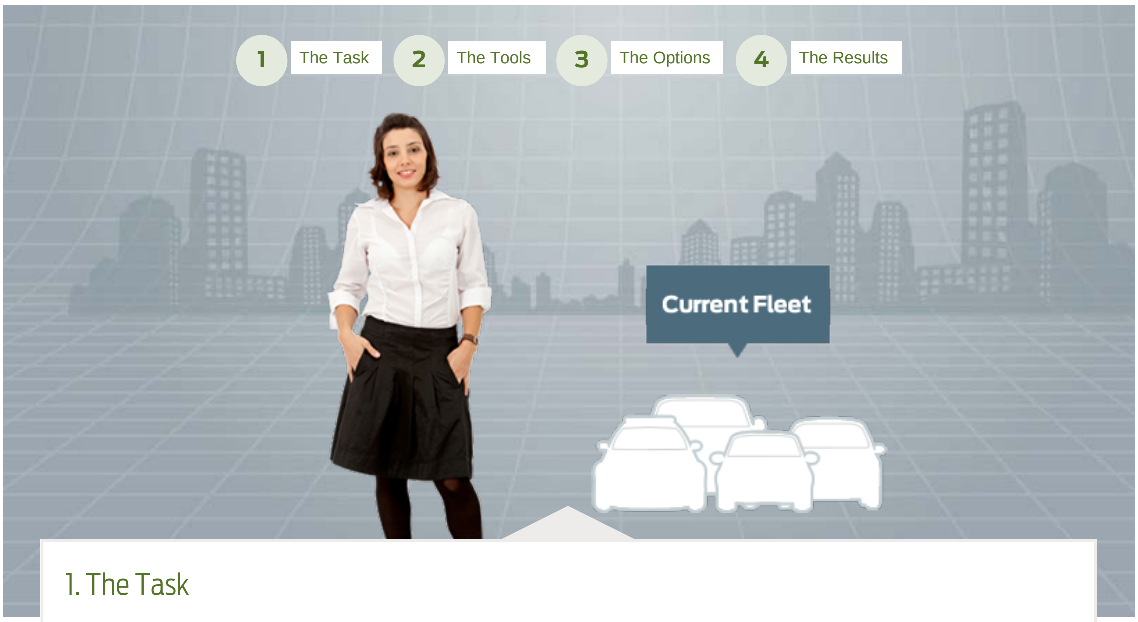
Case Study: Ford Fleet Purchase Planner



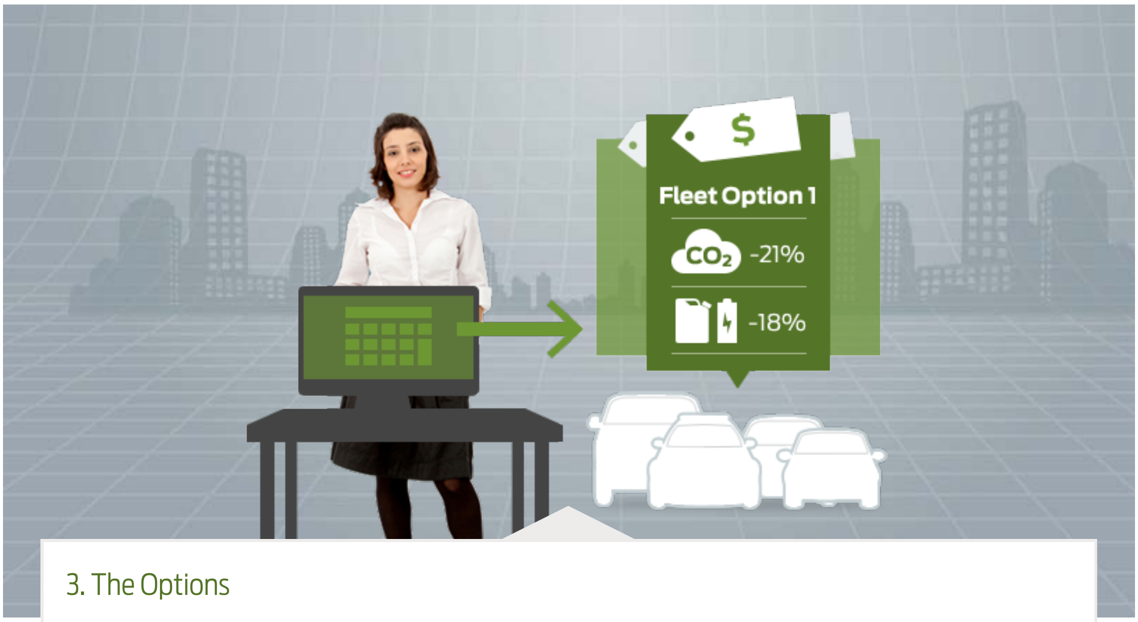
1. The Task

Scenario: Sam Smith is the Purchasing Manager for Green City, U.S.A.; she purchases about 100 new vehicles per year.

Her challenge is to help reduce the city's overall fleet emissions. She doesn't have the information she needs to assess the emissions of her current vehicle fleet and measure improvements over time. And, it's complicated and time-consuming to weigh the relative benefits and costs of so many alternative fuel and powertrain technologies to decide which are best for her fleet's drivers.

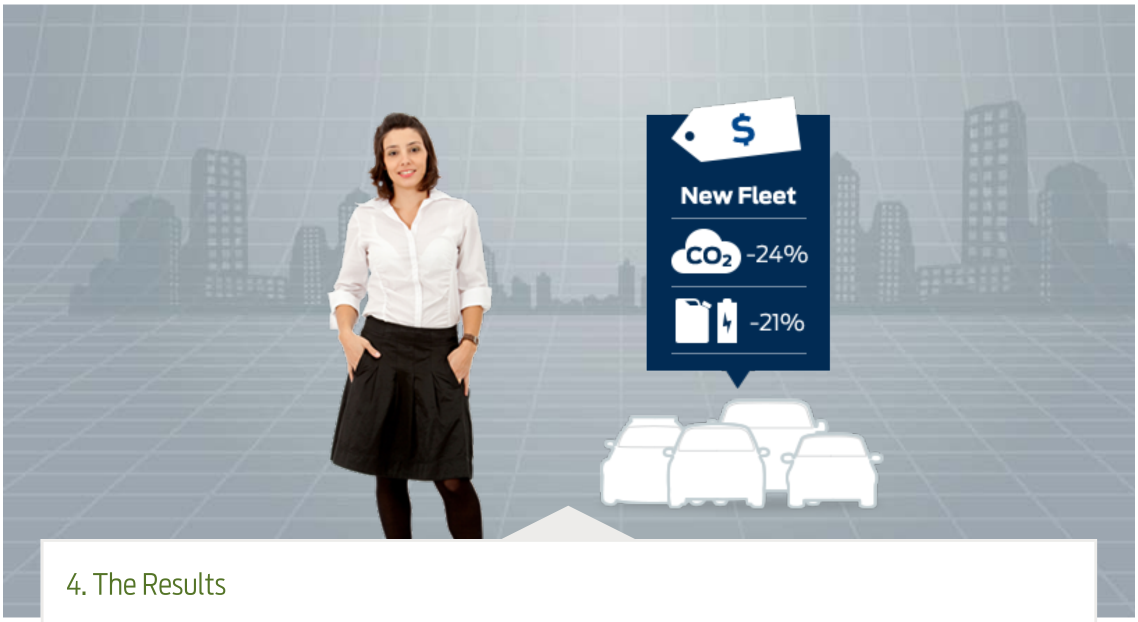
2. The Tools

Ford's suite of fleet purchasing tools helps Sam make an informed and effective decision. She can calculate the carbon dioxide (CO_2) footprint of her existing fleet, including factors like local fuel costs, electricity costs, electricity sources, miles driven and driving patterns. The tools can also show her the emissions and fuel cost reductions she would get from buying EcoBoost®-powered vehicles, hybrids, plug-in hybrids or battery electric vehicles, rather than just conventional internal combustion engine vehicles.



3. The Options

Ford's Purchase Recommender gives Sam a range of vehicle purchase options. It makes a recommendation for the vehicle mix that will provide the greatest emissions reduction at the lowest cost. And, it makes additional recommendations for how she can lower her emissions even more, if she has a little flexibility with her budget.



4. The Results

Sam makes a proposal to her management about the best set of vehicles to buy. She explains the specific emission and fuel-cost benefits of different vehicle technologies. And, Sam knows the CO_2 footprint of her existing fleet so she can accurately measure how much she would improve it with her proposal, and how much progress she can make toward the city's sustainability goals.

The growth in eco-conscious vehicle options is great news for customers who want to reduce their environmental footprint and save money on fuel. However, all the new choices do make planning purchases more complicated. Customers now have to determine which vehicle technologies will have the greatest environmental and cost benefits for their specific driving needs. This is especially true for commercial and government fleet customers, who often buy large numbers of vehicles and have to meet a wide range of transportation requirements across a variety of different driving situations.

Researchers at Ford have developed a suite of tools, collectively called the Ford Fleet Purchase Planner™, to help fleet buyers weigh all their options. These tools help buyers choose the best vehicles from Ford's lineup to manage their costs and reduce their company's carbon footprint. Fleet customers work with their Ford account manager or a fleet analyst to use the Planner to build a custom fleet of Ford vehicles. Buyers are then able to change their hypothetical fleet until the vehicle mix meets their specific costs and environmental goals.

The Fleet Purchase Planner™ includes several tools. First, it offers an Emissions and Fuel Cost Calculator, which compares the CO_2 emissions and fuel cost of two vehicles or vehicle technologies based on their fuel economy and customer-specific factors such as annual miles driven, city versus highway driving conditions and local fuel prices. The results help our customers understand the relative benefits of different technologies, such as an EcoBoost engine compared with a hybrid vehicle; different fuels, like gasoline versus compressed natural gas or diesel; and, for plug-in vehicles, different electricity carbon footprints in different regions of the country. For example, for customers deciding where to place battery electric vehicles in their fleets, the Calculator shows that the Focus Electric emits about 70 g CO_2 equivalent/km using electricity from the low-carbon California grid but more than twice as much, about 150 g CO_2 equivalent/km, in the more coal-intensive Southeast U.S.

But most fleets deal with hundreds or thousands of vehicles. Comparing all the available vehicle and technology replacement options for cost and sustainability across a fleet of many vehicles is a complex task. So, we developed additional tools to help fleets meet this challenge.

The Fleet CO_2 Footprint Status Calculator helps fleets calculate the carbon footprint of their current fleet. Customers provide a list of the Vehicle Identification Numbers (VINs) for all the vehicles in their fleet, and can customize this carbon footprint by adding in specific details on the locations of their vehicles, alternative fuels used, annual mileage, driving patterns and other criteria. This tool also calculates the annual fuel cost for the whole fleet. The CO_2 footprint and fuel cost become the baselines for evaluating the benefit of new vehicle purchases.

Finally, the Purchase Recommender helps fleet customers determine the right combination of replacement vehicles to meet their cost and environmental goals. Customers choose the type of cost they want to minimize: purchase price, purchase price plus fuel cost, or total cost of ownership. Then the Purchase Recommender calculates the exact combination of new vehicles they should buy to meet the same transportation needs as the vehicles they are replacing while minimizing their costs and CO_2 footprint. It also shows customers combinations of vehicles they could buy to make even greater reductions to the overall CO_2 footprint of their fleet, including the associated purchase price and fuel costs.

This tool is delivering benefits to Ford’s fleet customers and the environment. By using this tool, KONE, a leader in elevator and escalator manufacturing, has decided to replace its fleet of 160 Ford Fusion cars with the new Fusion Hybrid by 2018, resulting in a reduction in KONE’s carbon emissions of 850 metric tons – while also saving the company money.

The Ford Fleet Purchase Planner™ is part of Ford’s larger commitment to using data and analytics to benefit our customers and the environment. The unique tool was among three finalists for the 2014 Innovative Applications in Analytics Award by INFORMS, the largest association for professionals in analytics. Ford also won the 2013 INFORMS Prize, which acknowledges a company’s overall achievement in analytics.

Climate Change and the Environment

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- Climate Change
- Greening Our Products
- Greening Our Operations
- Data
- Case Study: Ford Fleet Purchase Planner
- **Voice: John Fleming**

Voice: John Fleming

Executive Vice President, Global Manufacturing and Labor Affairs, Ford Motor Company

“There are any number of investments a company like ours can make to better manage its environmental footprint. But there’s a balancing act when choosing which ones to implement. Sometimes it’s an easy decision and the returns on investment are immediate. Other times, you have to take a much longer view and accept the fact that it will take time to realize the financial gains.”

Here at Ford, we take environmental considerations into account at every stage of manufacturing. At the most basic level, there’s the issue of compliance. We want to be sure that what we do every day stays within the law and that we are operating as good neighbors.

But our efforts go well beyond mere compliance. We want our facilities to be the best in the world when it comes to our environmental footprint. Our Environmental Operating System, which offers a disciplined and common approach to manufacturing, is designed so that each of our facilities can learn from the others. We share best practices and apply leading technologies that help to minimize our impacts. We have also developed challenging improvement goals for all our operations in key environmental areas, such as our goal to reduce facility CO_2 emissions by 30 percent per vehicle produced from 2010 to 2025. And, we set specific annual improvement targets for every facility to make sure we meet or exceed these goals.

We have a standard set of environmental systems that are applied globally across all of Ford, enabling each of our 65 manufacturing facilities to operate under the same criteria when it comes to energy use and greenhouse gas emissions, water consumption and waste management. We monitor and measure our plants every day and, if problems are found, we immediately set to work to correct the issues.

Beyond incremental improvements, we are always looking for opportunities to make more substantive changes. When we’re building new plants or revamping product lines, we explore all sorts of opportunities that can take our facilities to the next level – from management practices such as shutting down parts of the plant when not in use to more complex manufacturing improvements that use the latest in cutting-edge technologies.

In 2014, we’re launching a historic number of products around the world. From the manufacturing perspective, we’ve been preparing for these launches since these new vehicles were in the earliest of development phases. It takes, on average, more than three years for a new vehicle to move from an initial concept to full production. Right from the start of a new product, we plan out a production road map that will allow us to build the vehicle in the most environmentally friendly way possible.

For every new vehicle we create, we follow a 100-point environmental checklist that helps us identify the production and facilities improvements we can make as we’re pushing it through development. The same 100-point system is also used to pinpoint and evaluate environmental best practices at new plants as well as older plants that are getting a significant refresh. We rate each plant on four key environmental areas that we then use to set targets and improvement goals.

When we consider building a new plant, we look at the same issues no matter where we are thinking of locating the facility – air emissions, water usage, waste water and waste. But of course the emphases may vary depending on the local conditions.

One of our biggest areas of focus is water use. Water conservation is a bigger problem in some countries than others, but water consumption is a critical issue for the planet no matter where we operate. We are proud to say that we achieved our 30 percent per vehicle water reduction target two years ahead of schedule.

There are any number of investments a company like ours can make to better manage its environmental footprint. But there’s a balancing act when choosing which ones to implement. Sometimes it’s an easy decision and the returns on investment are immediate. Other times, you have to take a much longer view and accept the fact that it will take time to realize the financial gains. For example, we have given ourselves the task of reducing energy consumption per vehicle globally by 25 percent, from 2011 to 2016. Several projects we have completed – such as solar panels at our Michigan Assembly Plant and windmills in Europe – will take many years to recover the outlay of expenses. The fact that we are willing to invest in projects with a long-term return on investment shows that Ford is willing to take a broad view of our business. We want to be good neighbors and we want to contribute to a better world.

Of course, we won't make an investment in a project that makes no business sense whatsoever. It has to have a relationship to the business but it doesn't necessarily have to pay back quickly for us to pursue it. In some cases, projects may have no payback at all but they help us to learn more cost-effective ways to make operational changes that will ultimately reduce our impacts.

There are many environmentally friendly projects we have instituted that I'm especially proud of – from the three-wet paint system, which reduces CO_2 emissions, improves energy and reduces volatile organic compounds (VOCs), to dry machining, which can save more than 280,000 gallons of water per year on a typical production line.

I was just 16 years old when I started as an apprentice at Ford in 1967 and I never left. We are so much more aware of our environmental impacts these days than we were back then and we have truly integrated environmental concerns into our business. Just think about our One Ford goal – great products, strong business and a better world. Forty years ago, we hardly focused on the negative impacts our company could have on our planet. Today, it's one of our top considerations.