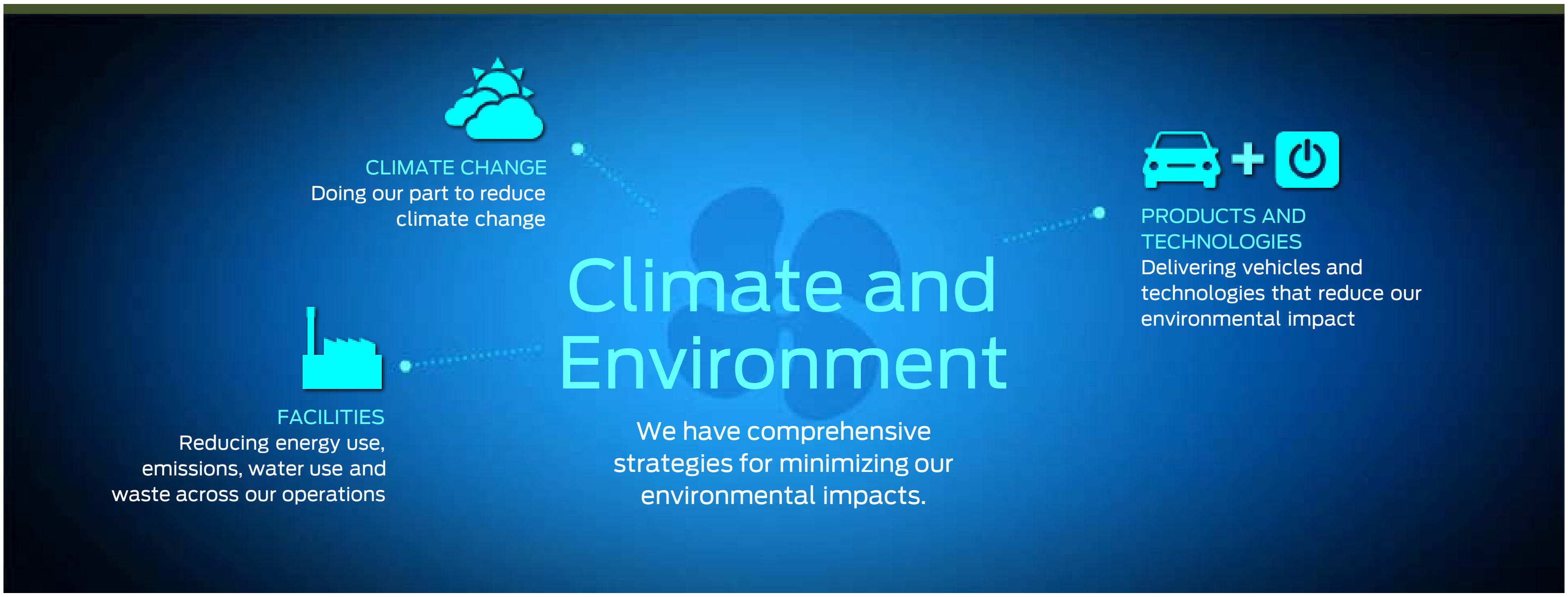





## At Ford, we have been working for many years to minimize the environmental impacts of our vehicles and operations.

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: Each of our new vehicles is a leader, or among the leaders, in 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.

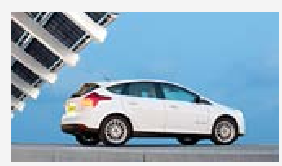
We are committed to reducing other elements of the environmental footprint of our vehicles and operations as well. For example, we continue to increase the use of sustainable materials in our vehicles. And, we reduced waste to landfill by 17 percent per vehicle from 2011 to 2012 and announced a new plan 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.

We plan to reduce waste sent to landfill per vehicle by

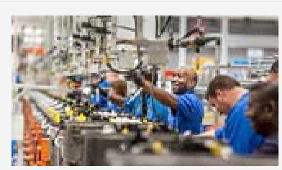
**40 percent**

between 2011 and 2016 globally.



### Electrifying Choices

We're continuing to expand our range of affordable, fuel-efficient and advanced technology vehicles, including six electrified vehicle options and eight vehicles that get 40 mpg or better.



### Reducing Energy Use

In 2012, we improved global energy efficiency by 6.4 percent against a 2011 year baseline normalized for weather and production levels.

# Design for Lifecycle Sustainability

We use a lifecycle approach to assess and minimize the total adverse impacts of our vehicles from a sustainability perspective – from raw materials extraction through manufacturing and use to end of life. This approach considers and works to minimize negative impacts upfront in product design decisions. Called Design for Sustainability (DfS), the approach is integrated and holistic, to ensure that we achieve a balance between environmental, social and economic aspects in our product development process.

We are continuing to advance how we apply DfS principles. For example, we developed a Product Sustainability Index (PSI) tool, which has been used in our European product development operations since 2002. This tool helps us to assess and find opportunities to reduce the impacts of our products over their entire lifecycle – 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. The PSI is used by the engineering teams that are responsible for product development decisions. We use other lifecycle assessment approaches in research and sustainability departments to address general strategic questions that are not necessarily linked to individual vehicle development programs.

We are working to improve the lifecycle 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 our EcoMode and Smart Gauge® with EcoGuide 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.

## Related links

This Report
- Product Sustainability Index
- Sustainable Materials
- Greening Our Operations
- Greening Our Products
- Supply Chain

# Quantifying Our Environmental Impact

The first step in improving the lifecycle performance of our products is to understand the environmental aspects of our products and the potential environmental impacts associated with them.[1] We use lifecycle assessment to understand the impacts of our vehicles. Lifecycle assessment tracks emissions generated and materials and energy consumed for a product system over its entire lifecycle, from cradle to grave, including raw material acquisition, material production, product manufacture, product use, product maintenance and disposal at end of life. For vehicles, this includes the environmental burdens associated with mining ores, making 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, recycling and reusing materials as possible and disposing of materials as necessary. Lifecycle assessment is an essential tool for thinking about the environmental impacts of complex systems.

Estimates of vehicles' total lifecycle impacts vary depending upon the specifics of the vehicle analyzed and the vehicle's powertrain and fuel type. For example, assessments of the Ford Fiesta, Focus and Mondeo – conducted using our Product Sustainability Index (PSI) tool – found significant differences in lifecycle carbon dioxide ($CO_2$) emissions between 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 lifecycle $CO_2$ emissions (for example, 77 percent of the total for the Focus diesel and 83 percent for the Mondeo gasoline). Vehicles with better fuel economy do reduce the use phase's contribution to lifecycle $CO_2$ emissions; however, the use phase remains the dominant phase for most environmental impacts. See the table below for comparisons of lifecycle $CO_2$ emissions across these three vehicles.

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

| Vehicle Model | Engine | Fuel Type | Lifecycle $CO_2$ emissions |
|---|---|---|---|
| 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

The PSI results also show that these vehicles made progress on multiple aspects of sustainability compared to the previous models. For more information on the PSI, please see the PSI section.

## Assessing the Lifecycle Emissions of Electrified Vehicles

Assessing vehicles' lifecycle energy consumption and greenhouse gas emissions is becoming a more complicated task as we add alternative fuels and powertrains into our vehicle lineup. For conventional gasoline- and diesel-powered vehicles, most of the energy is consumed and most of the lifecycle $CO_2$ emissions are released when the vehicles are driven, rather than when they are

Related links

This Report
- Electrification: A Closer Look
- Product Sustainability Index

Vehicle Websites
- Focus Electric
- C-MAX Energi
- Fusion Energi
- Fusion Hybrid
- C-MAX Hybrid
- Lincoln MKZ Hybrid

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 lifecycle $CO_2$ 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 lifecycle emissions.

In 2012, we launched our carbon emissions and fuel cost calculator to help our fleet sales teams in the U.S. and Canada work with customers to assess the emissions benefits of alternative-fuel vehicles. This calculator uses fleet customers' personalized input factors, such as vehicle type (e.g., hybrid, battery electric, diesel), electricity source by region (e.g., coal, nuclear, renewables, natural gas) and likely driving patterns (e.g., stop-and-go city traffic, highway driving or a mix). These key factors help determine the environmental benefits the customer might expect to achieve with each type of vehicle. For a customer deciding where to place an electric vehicle in their 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.

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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.

# Product Sustainability Index

Ford's European operations pioneered the development of the Product Sustainability Index (PSI), a holistic Design for Sustainability approach that incorporates societal and economic aspects as well as environmental aspects[1] into our lifecycle design approach.

Ford's PSI tracks eight product attributes identified as key sustainability elements of a vehicle: lifecycle global warming potential (mainly carbon dioxide emissions); lifecycle air-quality potential (other air emissions); the use of sustainable materials (recycled and renewable materials); vehicle interior air quality (including allergy certification from TÜV Rheinland, a product-testing organization); 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 lifecycle 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. The PSI process was used to develop the 2006 Ford S-MAX and Galaxy, as well as the 2007 Mondeo, 2008 Kuga, 2009 Fiesta and 2011 Focus. The Focus is the first Ford vehicle developed using the PSI system that is being sold globally. And, the PSI assessment of the Focus was the first PSI study conducted jointly by Ford of Europe and Ford North America. 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 to 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.

In 2012, we applied the PSI tool to various propulsion technologies for a Focus vehicle type. We learned that for a battery electric vehicle (BEV) variant, the carbon footprint of the battery is only about 10 percent of the overall lifecycle $CO_2$ emissions of a modern gasoline Focus. The carbon footprint of the electricity source used to charge the electric vehicle determines whether or not the Focus BEV is superior to a conventional Focus. In our study, we assumed the Focus BEV used electricity from sources below 400 g of lifecycle $CO_2$/kWh – such as the electricity currently used in California, Norway, Switzerland and France. 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. In 2013, we will continue in this study by assessing plug-in hybrid vehicles.

## PSI Assessed Model Performance[2]

### Lifecycle Global Warming Potential[2]

#### Measurement 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 |
|---|---|---|
| 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 |
| 2007 Ford Mondeo 2.0L TDCi Diesel with DPF | 37 metric tons $CO_2$ equivalent | Better |
| 2008 Ford Kuga | 37 metric tons $CO_2$ equivalent | No previous model |

| | | |
|---|---|---|
| 2009 Ford Fiesta ECOnetic, Diesel | 21 metric tons $CO_2$ equivalent | Better |
| 2009 Ford Fiesta, Gasoline | 30 metric tons $CO_2$ equivalent | Better |
| 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 |

*1 metric ton = 1,000 kg

## Lifecycle Air Quality

### Measurement 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 |
|---|---|---|
| 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 |
| 2007 Ford Mondeo, 2.0-L TDCi Diesel with DPF | 35 kg ethene equivalent | Better |
| 2008 Ford Kuga | 35 kg ethene equivalent | No previous model |
| 2009 Ford Fiesta ECOnetic, Diesel | 22 kg ethene equivalent | Better |
| 2009 Ford Fiesta, Gasoline | 32 kg ethene equivalent | Better |
| 2011 Ford Focus, 1.6 L, Gasoline | 30 kg ethene equivalent | Better |
| 2011 Ford Focus, 1.6L Diesel | 25 kg ethene equivalent | Better |

## Sustainable Materials

### Measurement Method

Use of recycled and natural materials

| | Performance | Better/Worse than Previous Model |
|---|---|---|
| 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 |
| 2007 Ford Mondeo 2.0L TDCi Diesel with DPF | 7.5% of non-metals | Better |
| 2008 Ford Kuga | 6% 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 |

## Substance Management

| | Performance | Better/Worse than Previous Model |
|---|---|---|
| 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 |
| 2007 Ford Mondeo, 2.0L TDCi Diesel with DPF | 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 |
| 2009 Ford Fiesta ECOnetic, Diesel | Substance management, | Better |

| | | |
|---|---|---|
| | TÜV-tested interior and pollen filter efficiency | |
| 2009 Ford Fiesta, Gasoline | Substance management, TÜV-tested interior and pollen filter efficiency | Better |

## Drive-by-Noise

### Measurement Method

Decibel level weighted to human ear dB(A)

| | Performance | Better/Worse than Previous Model |
|---|---|---|
| 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 |
| 2007 Ford Mondeo 2.0L, TDCi Diesel with DPF | 69 dB(A) | Similar |
| 2008 Ford Kuga | 72 dB(A) | No previous model |
| 2009 Ford Fiesta ECOnetic, Diesel | 69 dB(A) | Better |
| 2009 Ford Fiesta, Gasoline | 72 dB(A) | Similar |
| 2011 Ford Focus, 1.6L Gasoline | 66 dB(A) | Better |
| 2011 Ford Focus, 1.6L Diesel | 68 dB(A) | Better |

## Safety

### Measurement 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 |
|---|---|---|
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |

## Mobility Capacity

### Measurement 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 |
|---|---|---|
| 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 |
| 2007 Ford Mondeo, 2.0L TDCi Diesel with DPF | 9 $m^2$ shadow area, 530 liter luggage, 5 seats | Better |
| 2008 Ford Kuga | 9.5 $m^2$ shadow area, 410 liter luggage, 5 seats | No previous model – among best in class |
| 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 |
| 2011 Ford Focus, Gasoline and Diesel | 8.76 $m^2$ shadow area, 363 liter luggage compartment | Similar |

## Lifecycle Cost

### Measurement Method

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

| | Performance* | Better/Worse than Previous Model |
|---|---|---|
| 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 |
| 2007 Ford Mondeo, 2.0L TDCi Diesel with DPF | Approx. €18,300 | Better |
| 2008 Ford Kuga | Approx. €19,100 | No previous model |
| 2009 Ford Fiesta ECOnetic, Diesel | Approx. €13,000 | Similar |
| 2009 Ford Fiesta, Petrol | Approx. €11,000 | Better |
| 2011 Ford Focus, 1.6L Gasoline | Approx. €16,400 | Better |
| 2011 Ford Focus, 1.6L Diesel | Approx. €16,700 | 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 lifecycle assessment and design tool. An external study, conducted by experts in lifecycle 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 lifecycle assessment standard. The PSI assessments of the 2006 S-MAX and Galaxy vehicles were certified against the ISO rules for Lifecycle Assessment. This certification process also verified the overall PSI methodology used for all subsequent PSI-developed models.

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.
2. PSI-rated models are only available in Europe.

# 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 carbon dioxide ($CO_2$) concentrations in the atmosphere 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:

- Each new or significantly refreshed vehicle will be best in class, or among the best in class, for 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 $CO_2$ emissions from our 2012 model year U.S. new vehicles by 15 percent compared to the 2007 model year
- Reduced fleet-average $CO_2$ emissions from our European vehicles by 14 percent from the 2006 to 2012 calendar years
- Reduced $CO_2$ emissions from our global operations in 2012 by 1 percent on a per-vehicle basis, compared to 2011
- Implemented three more engines with our patented EcoBoost® fuel-saving technology – in 2013, we expect to be producing approximately 1.5 million EcoBoost engines globally, about 200,000 more than originally expected
- For the 2012 model year, began selling the Focus Electric, which gets a combined 105 miles per gallon (mpg) equivalent (according to the U.S. Environmental Protection Agency), making it the most fuel-efficient compact vehicle in the U.S. at the time of launch
- Introduced two plug-in hybrid electric vehicles to customers in the U.S.: the C-MAX Energi and

## Related links

This Report

- Greening Our Products
- Greening Our Operations
- Sustainable Technologies and Alternative Fuels Plan
- Vehicle Fuel Efficiency and $CO_2$ Emissions Progress and Performance

Fusion Energi

- Offered three hybrid electric vehicle models: the Ford Fusion, Ford C-MAX and Lincoln MKZ
- In Europe, offered 39 models and variants that achieve a $CO_2$ emissions level of 130 grams per kilometer (g/km), and nine that achieve less than 100 g/km
- In North America starting in 2012, offered eight models that provide 40 mpg or better – compared to 2009, when our most fuel-efficient vehicle achieved 35 mpg

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 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.

## In This Section

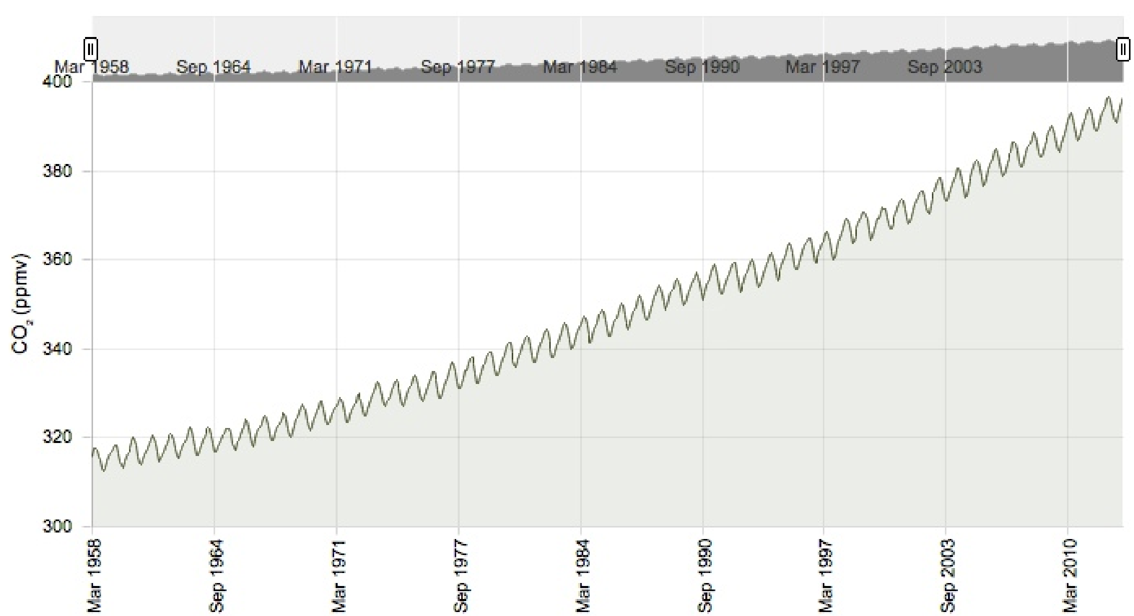
In this section we first provide an overview of the climate change issue and of Ford's greenhouse gas emissions. We also discuss the risks and opportunities that climate change poses for Ford and our overall climate change strategy. Finally we discuss climate change public policy issues and Ford's climate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

# The Issue

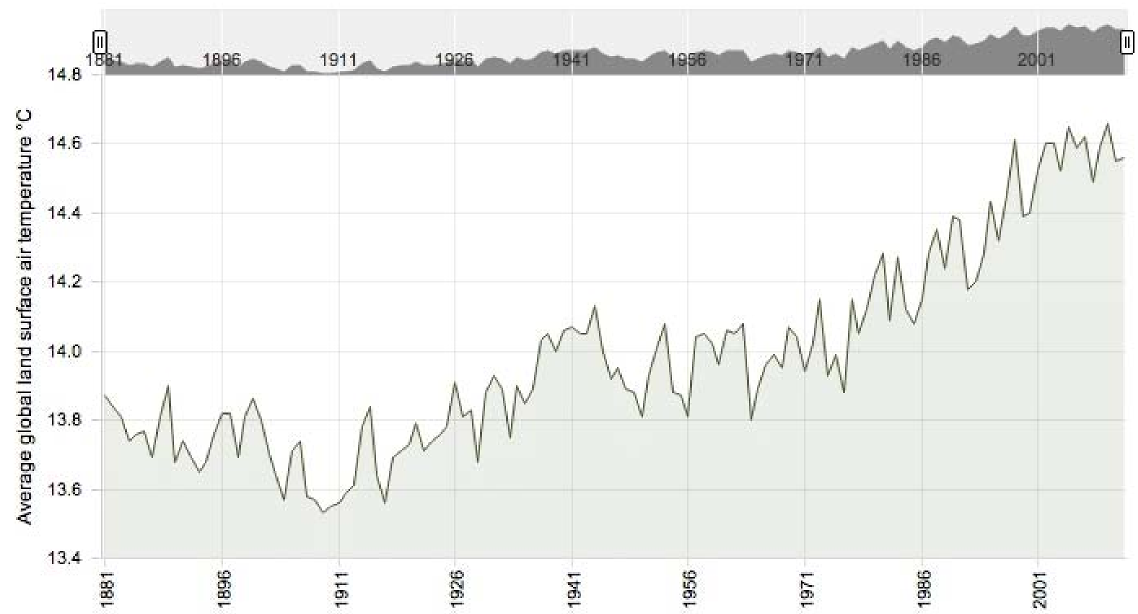
Climate change is the result of an increase in heat-trapping (greenhouse) gases in the atmosphere. Carbon dioxide ($CO_2$) is the major long-lived greenhouse gas (GHG). The burning of fossil fuels (to provide electricity, heat and transportation, and to support industry and agriculture), as well as deforestation, 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 270–280 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 in the U.S., the National Oceanic and Atmospheric Administration 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, the warming trend is continuing, and 2012 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



### Figure 2: Global temperature



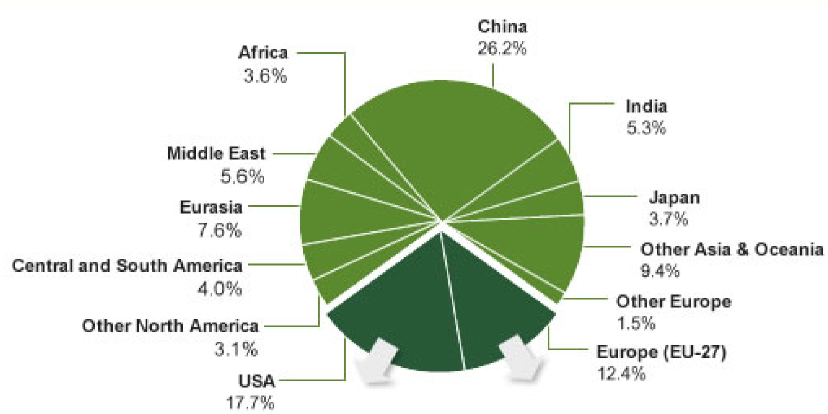

## Global Emissions

Figure 3 (below) provides a breakdown of estimated 2009 fossil fuel $CO_2$ emissions by region. For the U.S. and Europe, 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 4 percent of global fossil fuel $CO_2$ emissions. In Europe, passenger cars and light-duty trucks account for approximately 19 percent of fossil fuel $CO_2$ emissions, or about 3 percent of global fossil fuel $CO_2$ emissions.

Until approximately 2007, the U.S. was the largest $CO_2$ emitter. Due to economic development, however, emissions from China surpassed those from the U.S. about six years ago, and it is expected that the gap between emissions from China and those from the U.S. will continue to widen in the future. That said, 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.

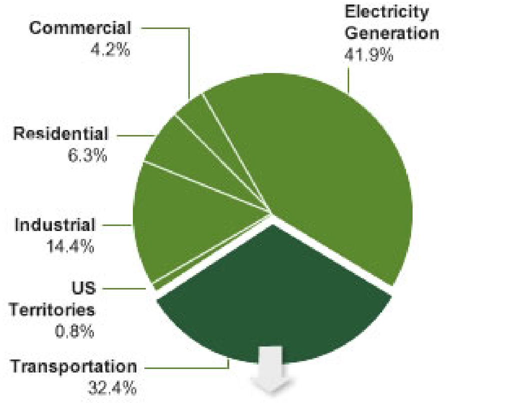
### Figure 3: Regional distribution of fossil fuel $CO_2$ emissions in 2010

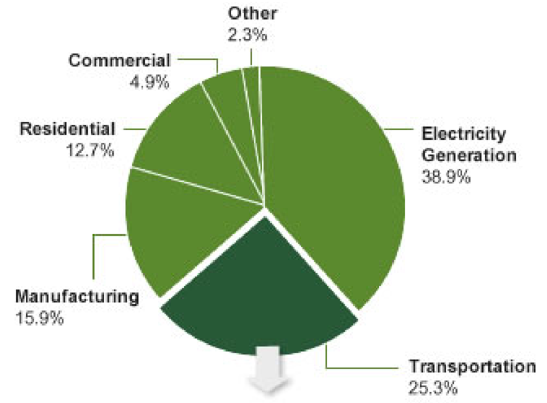
#### Global CO2 Emissions



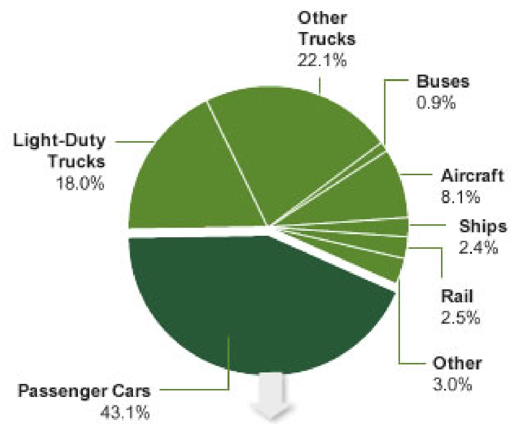

#### USA by Sector

#### Europe (EU-27) by Sector

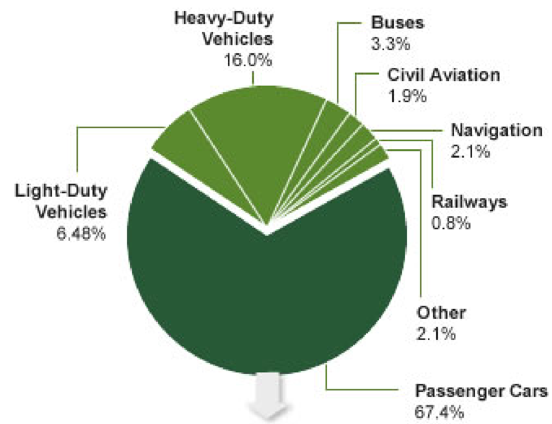


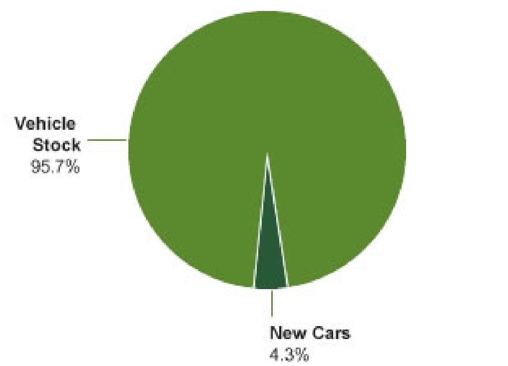

## USA Transportation



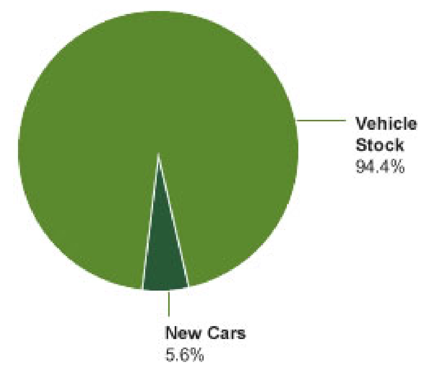

## Europe (EU-27) Transportation




## USA Passenger Cars




## Europe (EU-27) Passenger Cars




Global $CO_2$ Emissions

*Percent*

| | 2010 |
|---|---|
| USA | 17.7 |
| Europe | 12.4 |
| Other North America | 3.1 |
| Central and South America | 4.0 |
| Eurasia | 7.6 |
| Middle East | 5.6 |
| Africa | 3.6 |
| China | 26.2 |
| India | 5.3 |
| Japan | 3.7 |
| Other Asia & Oceania | 9.4 |

| | |
|---|---|
| Other Europe | 1.5 |

### USA by Sector

*Percent*

| | 2010 |
|---|---|
| Transportation | 32.4 |
| US Territories | 0.8 |
| Industrial | 14.4 |
| Residential | 6.3 |
| Commercial | 4.2 |
| Electricity Generation | 41.9 |

### Europe (EU27) by Sector

*Percent*

| | 2010 |
|---|---|
| Transportation | 25.3 |
| Manufacturing | 15.9 |
| Residential | 12.7 |
| Commercial | 4.9 |
| Electricity Generation | 38.9 |
| Other | 2.3 |

### USA Transportation

*Percent*

| | 2010 |
|---|---|
| Passenger Cars | 43.1 |
| Light-Duty Trucks | 18.0 |
| Other Trucks | 22.1 |
| Buses | 0.9 |
| Aircraft | 8.1 |
| Ships | 2.4 |
| Rail | 2.5 |
| Other | 3.0 |

### Europe (EU27) Transportation

*Percent*

| | 2010 |
|---|---|
| Passenger Cars | 67.4 |
| Light-Duty Vehicles | 6.48 |
| Heavy-Duty Vehicles | 16.0 |
| Buses | 3.3 |
| Civil Aviation | 1.9 |
| Navigation | 2.1 |
| Railways | 0.8 |
| Other | 2.1 |

### USA Passenger Cars

*Percent*

| | 2010 |
|---|---|
| Vehicle Stocks | 95.7 |
| New Cars | 4.3 |

### Europe (EU27) Passenger Cars

*Percent*

| | 2010 |
|---|---|
| Vehicle Stocks | 94.4 |
| New Cars | 5.6 |

# Beyond $CO_2$

While carbon dioxide 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 – the U.S. Environmental Protection Agency (EPA) estimates that they contribute less than 1 percent of vehicle greenhouse gas emissions – manufacturers must meet new standards for these emission constituents starting in 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 hydrofluorocarbons (HFCs), 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 2012, for example, we worked with an international team of climate and atmospheric scientists to assess the global warming potentials of long-lived greenhouse gases.

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.[2] We have presented a technical assessment arguing that time horizons of 20 years, or longer, are needed in assessments of the contribution of road transport to the radiative forcing of climate change.[3]

## 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 ($CF_2Cl_2$) 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 ($CF_3CFH_2$). 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,[4] compared to CFC-12's global warming potential of 10,900.

Related links
This Report
Sustainable Materials
External Websites
Montreal Protocol

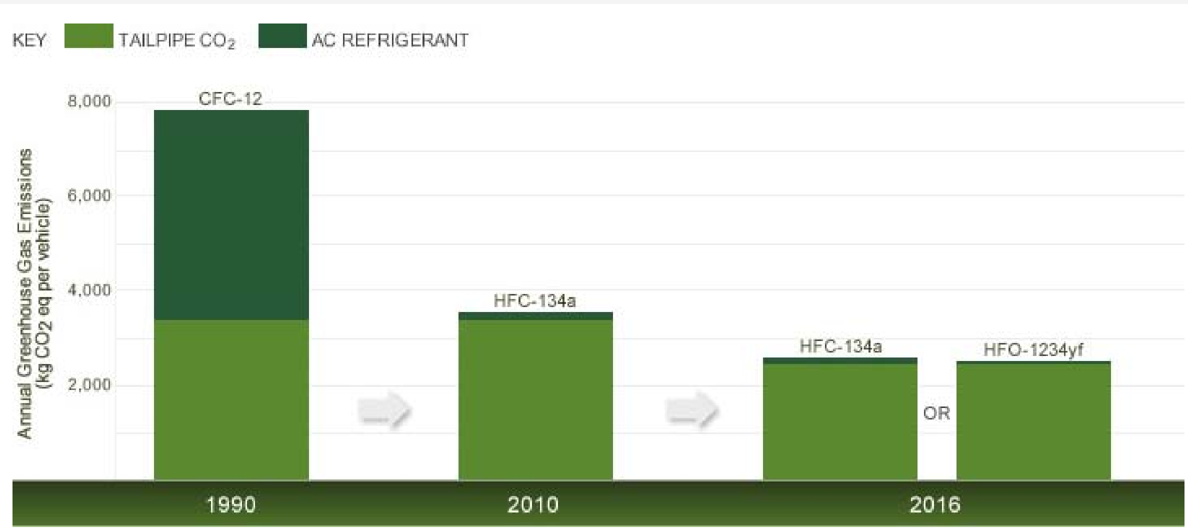
As seen in Figure 1 below, the lifecycle emissions of CFC-12 from an AC-equipped car in 1990 were approximately 400g per vehicle[5] – i.e., a $CO_2$ equivalent radiative forcing impact comparable to that of the $CO_2$ emitted from the tailpipe of the car. Replacement of CFC-12 with HFC-134a, together 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.[6] Looking to the future, based on published assessments,[7] we believe that HFC-134a emissions from a typical light-duty vehicle manufactured in 2017 will be approximately 50g 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 are required to use compounds with global warming potentials of 150 or less in the AC units for all approvals of new vehicle types beginning on January 1, 2011 (though this deadline was extended by moratorium until the end of 2012) and all registered vehicles beginning on January 1, 2017. Because HFC-134a has a global warming potential of 1,370, 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 $CF_3CF{=}CH_2$) for use in European vehicles subject to the above-mentioned legislation timing. Research at Ford[8] has established that HFO-1234yf has a global warming potential of 4. 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 lifecycle 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

| Compound | Chemical Formula | Safe for Ozone? | Atmospheric Lifetime[9] | Global Warming Potential[9] |
|---|---|---|---|---|
| CFC-12 | $CF_2Cl_2$ | No | 100 years | 10,900 |
| HFC-134a | $CF_3CFH_2$ | Yes | 13.4 years | 1,370 |
| HFO-1234yf | $CF_3CF{=}CH_2$ | Yes | 11 days | 4 |


1. T.J. Wallington, J.L. Sullivan and M.D. Hurley, "Emissions of $CO_2$, CO, NOx, HC, PM, HFC-134a, $N_2O$ and $CH_4$ from the Global Light Duty Vehicle Fleet," *Meteorol*. Z. 17, 109 (2008).
2. T.J. Wallington, J.E. Anderson, S.A. Mueller, S. Winkler and J.M. Ginder, "Emissions Omissions," *Science* 327, 268, (2010).
3. T.J. Wallington, J.E. Anderson, S.A. Mueller, S. Winkler, J.M. Ginder and O.J. Nielsen, "Time Horizons for Transport Climate Impact Assessments," *Environ. Sci. Technol*. 45, 3169 (2011).
4. World Meteorological Organization, *Scientific Assessment of Ozone Depletion*: *2010*, Geneva (2010).
5. IPCC/TEAP, *Special Report: Safeguarding the Ozone Layer and the Climate System*, Cambridge University Press, 2005.
6. T.J. Wallington, J.L. Sullivan and M.D. Hurley, "Emissions of $CO_2$, CO, NOx, HC, PM, HFC-134a, $N_2O$ and $CH_4$ from the Global Light Duty Vehicle Fleet," *Meteorol*. Z. 17, 109 (2008).
7. 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).
8. O.J. Nielsen, M.S. Javadi, M.P. Sulbaek Andersen, M.D. Hurley, T.J. Wallington and R. Singh, "Atmospheric Chemistry of CF3CF=CH2: Kinetics and Mechanisms of Gas-Phase Reactions with Cl Atoms, OH radicals, and O3," *Chem. Phys. Lett.* 439, 18 (2007).
9. WMO/UNEP, *Scientific Assessment of Ozone Depletion: 2010*, Geneva (2010). 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

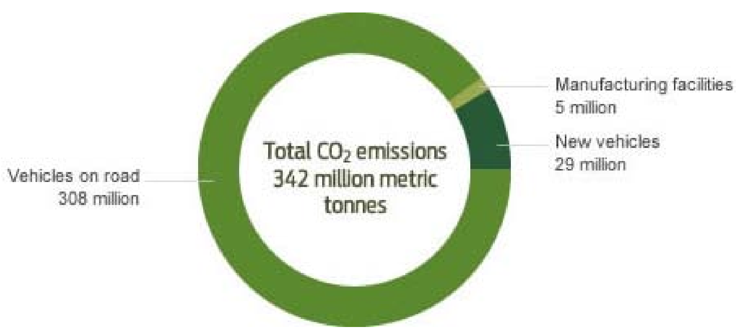
We estimate that annual carbon dioxide ($CO_2$) emissions from Ford facilities and Ford vehicles driven by our customers are in the range of 350–400 million metric tons (Mmt) per year, varying over time with fluctuations in vehicle production and sales, on-road fleet size and vehicle miles traveled. The estimate includes emissions from our facilities, emissions from current-year vehicles and emissions from all Ford vehicles 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, along with the estimates carried out in 2001 and 2006/7 for the years 1999 and 2005, respectively.

Please note that while we can exercise a significant degree of ongoing control over our facility emissions, we have essentially 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 currently 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, 2005 and 1999




*Metric tonnes*

| | $CO_2$ emissions |
|---|---|
| Manufacturing facilities | 5 million |
| New vehicles | 29 million |
| Vehicles on the 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. These estimates are fairly precise.[3] Facility GHG emissions, however, are a small percentage (about 2 percent) of the total.

Related links

This Report
- Supplier Greenhouse Gas Emissions

- Emissions from calendar year 2008[4] vehicles on the road decreased by about 22 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] These emissions account for about 8 percent of the total.
- Emissions from all Ford vehicles on the road are 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 precisely the emissions 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.



## 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 developments in natural gas shale, domestic oil discoveries and increased renewable fuel are the initial steps 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. Between 2006 and 2012, the U.S. Environmental Protection Agency (EPA) projects that the car share of the U.S. market increased from 57.9 percent to 63.9 percent, while the truck share declined from 42.1 percent to 36.1 percent. The EPA also projects that sales of small cars increased from 21.2 percent of sales in 2006 to 25.1 percent in 2012. And they project that sales of hybrid electric vehicles increased from 2.2 percent in 2011 to 3.7 percent in 2012.

In addition, over the past decade the use of ethanol in the U.S. gasoline market has shifted from approximately 10 percent of the available gasoline containing 10 percent ethanol (E10) in 2002, to the widespread availability of E10 in nearly all gasoline as of the end of 2012. 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 designed to encourage new vehicle sales, with the aim of reducing $CO_2$ emissions from older, less-efficient vehicles. Several European countries have $CO_2$-based taxation with aggressive tax break points, which has boosted sales of smaller, more fuel-efficient cars. In addition, tough new $CO_2$ emission regulations have 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 limited incentives to fleet purchasers of "new energy vehicles" (defined as battery electric and plug-in electric vehicles) through a pilot program in 25 cities that applies to vehicles 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 automatic 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 18 to 25 percent ethanol, and pure ethanol is also widely used. 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. Porsche, Mercedes and Toyota also offer hybrid vehicles 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.

In the first quarter of 2012, continued supply disruptions and instability in the Middle East and Africa contributed to a significant increase in world crude prices, resulting in record-high gasoline prices during 2012. However, more 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]

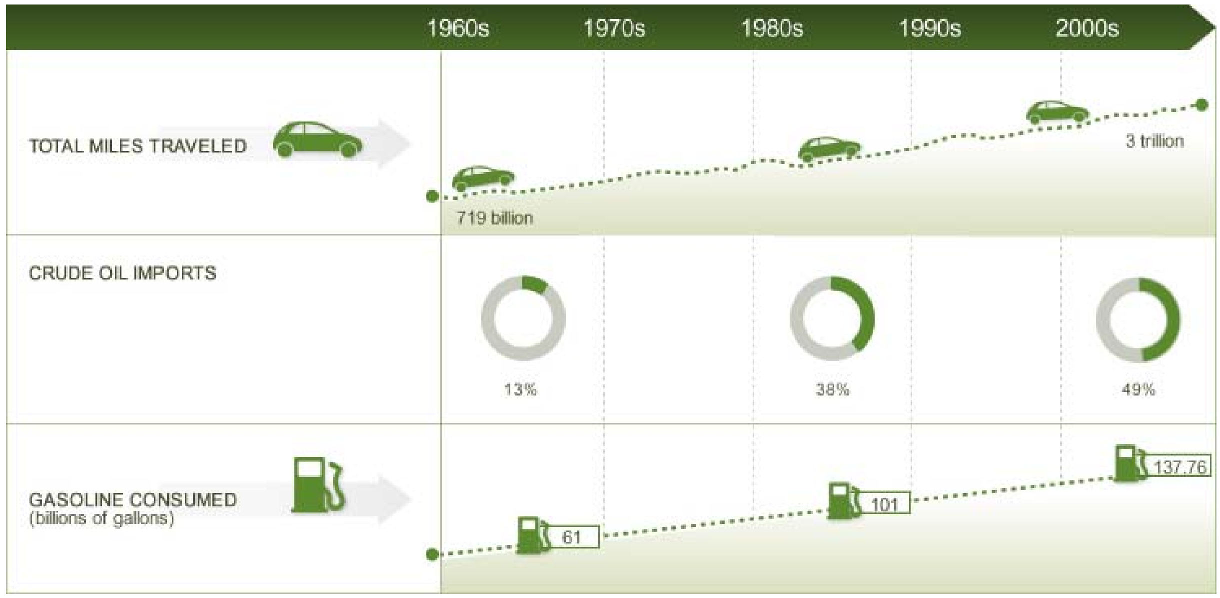
The U.S. marketplace has also seen the widespread penetration of renewable fuel use over the past 10 years. Today more than 90 percent of the gasoline offered for sale at retail refueling stations contains 10 percent ethanol (E10) by volume. The Energy Independence and Security Act of 2007 mandated increasingly 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 for U.S. consumers and continues to drive their vehicle purchase behavior, including demand for more fuel-efficient vehicles.

## Figure 1: Total Miles Traveled, Crude Oil Imports, 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.

Climate Change and the Environment

- Design for Lifecycle Sustainability
- Climate Change
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  - Ford's Greenhouse Gas Emissions
  - Climate Change Risks and Opportunities
  - Ford's Climate Change Strategy
    - Climate Change Strategic Principles
    - Ford's Science-Based $CO_2$ Targets
  - Climate Change Policy and Partnerships
- Greening Our Products
- Greening Our Operations
- Data
- Voice: Mark Lee

# 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
- 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.

## 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. In 2012, for example, small cars showed the largest market-share increase of any vehicle segment across the industry, posting a 23 percent increase compared with overall industry expansion of just 13 percent. Ford's sales of small cars were up 29 percent in 2012, giving us just over 10 percent of the small-car segment, more than a full percentage point increase compared to 2010, and our best share of the U.S. small-car segment since 2003. The Ford Focus was the best-selling car, worldwide, in 2012.

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

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This Report

- Sustainable Technologies and Alternative Fuels Plan

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 the atmosphere's concentration of greenhouse gases. Once those molecules reach the atmosphere, they contribute to the greenhouse effect, regardless of the 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 link in this chain depends on the others. For example, vehicle manufacturers can bring to market flexible-fuel vehicles, but successfully reducing GHG emissions with them will depend on fuel companies providing renewable biofuels, as well as consumer demand for the vehicles and fuels.

3. Future developments in technologies, ever-changing markets, consumer demand and political uncertainties require flexible solutions. 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

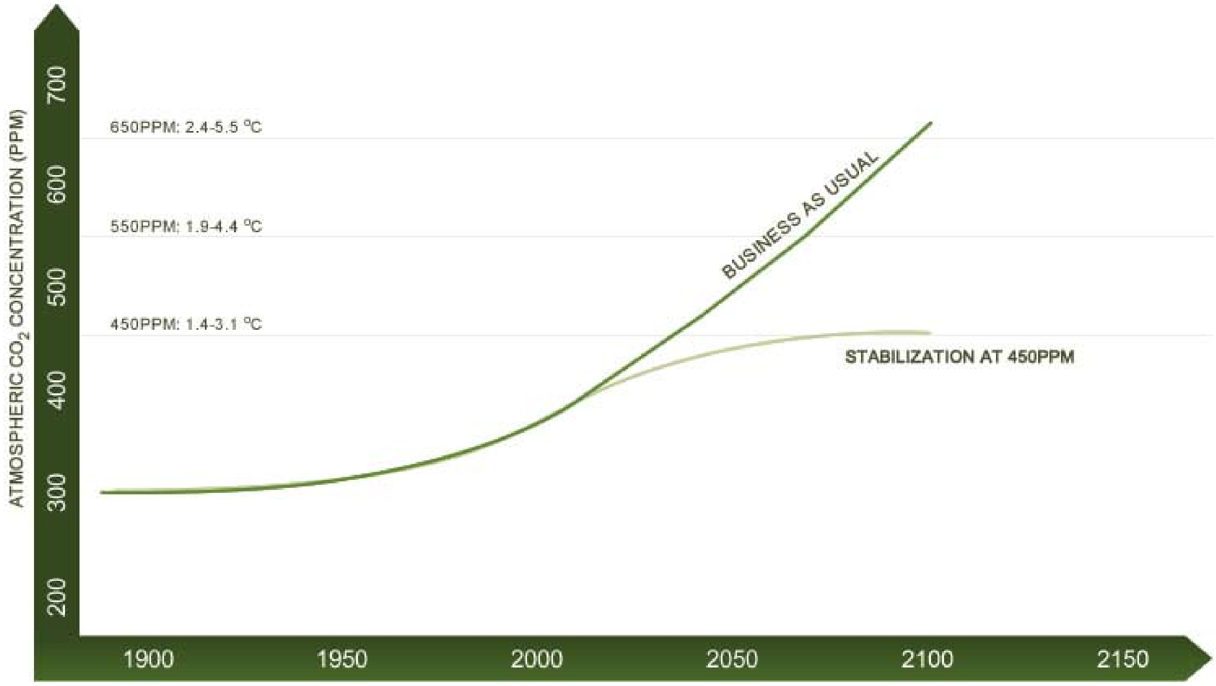
Throughout this report, we refer to Ford's climate goals as "science-based" – specifically, based on the science of climate stabilization. An advantage of this approach is that it gives us an objective, long-term goal focused on an environmental outcome – the stabilization of carbon dioxide ($CO_2$) 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. 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

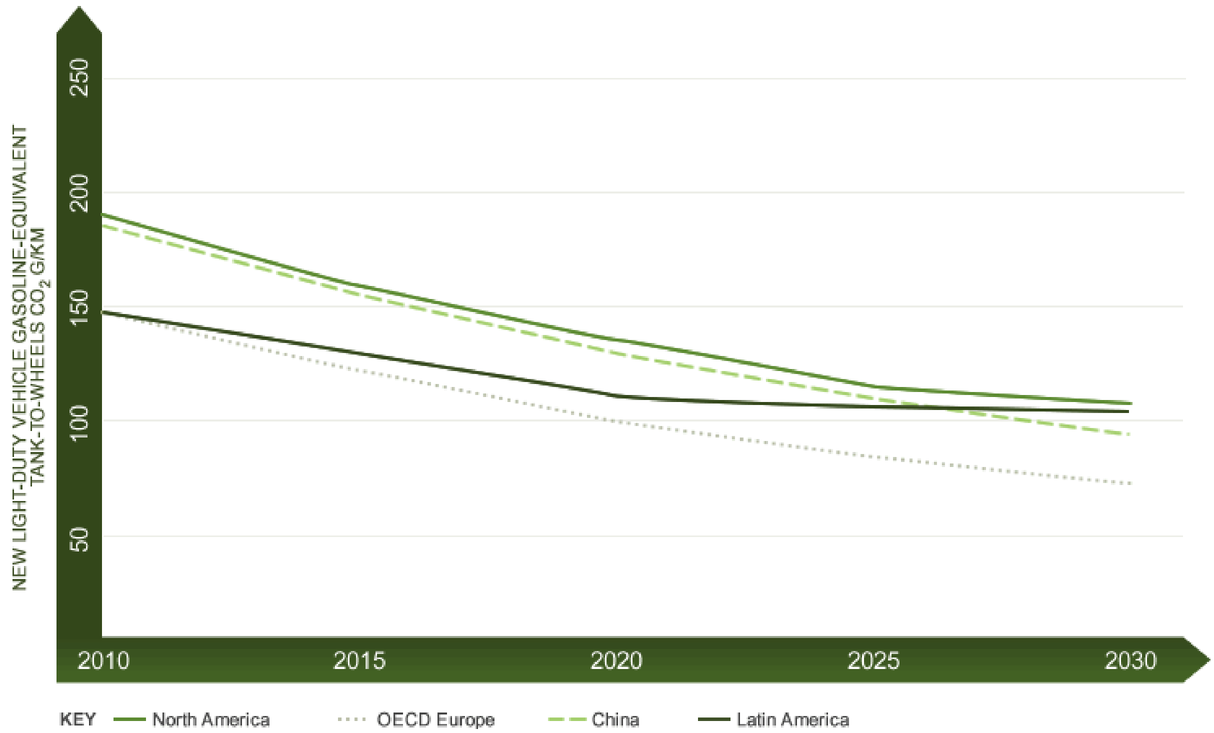
Ford researchers have played a leading role in scientific research to understand and quantify the contribution of vehicles to climate change. We have also worked with a variety of partners to understand current and projected manmade greenhouse gas (GHG) emissions and the steps that can be taken to reduce 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 this level. We then calculated the long-term, sustained reductions in the $CO_2$ emission rate (g/km) from new LDVs that would be needed 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 the effects of 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 same proportion as 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.

## Industry-Average $CO_2$ Glide Paths[1]




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

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.

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 $CO_2$ 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 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.[2] 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. E.U. and China glidepaths were developed based on the New European Driving Cycle (NEDC) and North America and Latin America glidepaths 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.
2. 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. Joint investigations with BP provided insight into how the best new vehicle technologies and low-carbon alternative fuels can jointly and realistically fulfill the low-$CO_2$ emission requirements. Ford's $CO_2$ model and other modeling tools were 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 roadmap. 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.

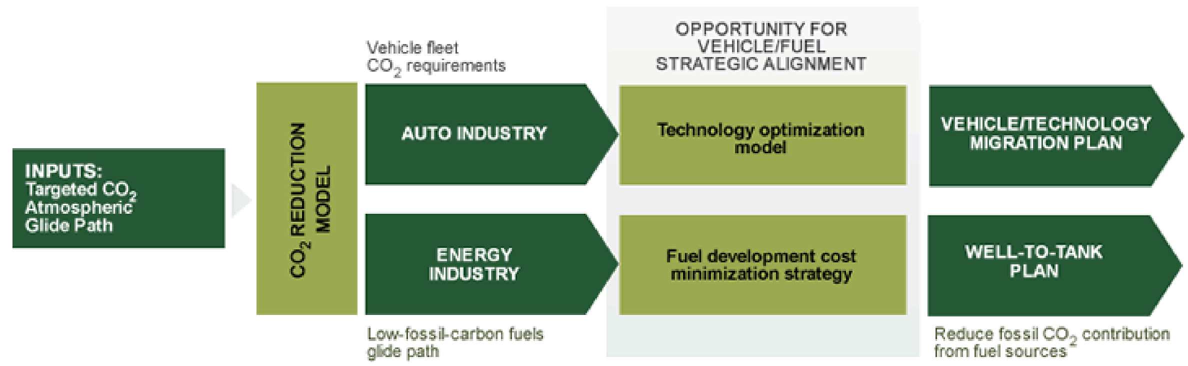
## Are you continuing to test alternative scenarios?

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 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

During 2012, the climate change policy landscape continued to evolve. 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 2017–2025. Globally, however, growing budget deficits at national and regional levels have overshadowed climate policy discussions over the last several years.

Our global approach to product planning and policy participation is based on the science of climate stabilization. We accept that simply “not getting worse” is not good enough. The auto industry must work together with suppliers, government, the fuel industry and consumers to reduce carbon dioxide ($CO_2$) levels from transportation so we can help stabilize atmospheric $CO_2$ concentrations. Stabilizing $CO_2$ concentrations will require that all sectors of the economy, including the transportation sector, do their share. Ultimately, to achieve real and lasting results, all global stakeholders must also make long-term commitments for a sustainable future.

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.

In the U.S. and elsewhere, Ford continues to advocate for comprehensive, market-based policy approaches that will provide a coherent framework for greenhouse gas (GHG) emission reductions, so that companies have a clear understanding of their role in achieving reductions. GHG regulations effectively regulate what vehicles we are allowed to build and sell. $CO_2$ emissions standards for motor vehicles are functionally equivalent to fuel economy standards, because the amount of $CO_2$ produced by a vehicle is proportional to the amount of fuel used.

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. US EPA g $CO_2$/mi
2. US EPA g $CO_2$/mi and mpg
3. US EPA g $CO_2$/km, km/L
4. US EPA MJ/km, km/L
5. NEDC g CO /km
6. NEDC L/100 km
7. US EPA or NEDC g CO /km
8. 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

ON THIS PAGE

- Climate Change Legislation
- Greenhouse Gas and Fuel Economy Regulation

Related links

External Websites

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

## 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) has continued to pursue greenhouse gas (GHG) emissions regulations for mobile sources using their authority under the Clean Air Act, while the U.S. National Highway Transportation Safety Administration (NHTSA) has continued to pursue fuel economy regulations. In 2012, the EPA and NHTSA finalized joint greenhouse gas emission and fuel economy regulations for 2017–2025 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 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 nearly 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.

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 2012–2016 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 2017–2025 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 2017–2021, and about 5 percent per year for model years 2022–2025.

It is important to note that the EPA's 2022–2025 GHG standards are final rules; in contrast, NHTSA's 2022–2025 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 would depend 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 2022–2025 in order 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 2017–2025 model years.

Ford plans to participate in the mid-term evaluation process. For the longer term, Ford supports a legislative solution codifying the One National Program approach beyond 2025, in order 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.

As with the 2012–2016 rules, the 2017–2025 rules have been challenged in federal court by entities whose primary concern appears to be the ramifications of the vehicle rules on stationary source regulation. The automotive industry has intervened in the litigation with the goal of avoiding adverse changes to the One National Program rules.

While the new rules are challenging, we believe they are feasible in light of our product plans and projected market conditions for the time period covered by our product planning process. We intend to work closely with the EPA, NHTSA and other key stakeholders, including California, throughout the mid-term evaluation process to ensure continued alignment between regulatory goals and market realities for the 2022 through 2025 model years.

In October 2011, the EPA and NHTSA also finalized a single national program for greenhouse gas and fuel economy standards for heavy-duty vehicles. The $CO_2$ and fuel-consumption requirements for the 2014 through 2018 model years target combination tractors, heavy-duty pickup trucks and vans, and vocational vehicles. The agencies estimate that the combined proposed standards have the potential to reduce GHG emissions by nearly 270 million metric tons and save approximately 530 million barrels of oil over the life of these vehicle types sold during the program. A second phase of regulations is planned for model years beyond 2018.

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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 2012–2015 period. This target is set to decrease to 95 g/km in 2020; however, the modalities of reaching the 2020 target are set to be reviewed and further detailed in 2013.

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, among others. 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, electro-magnetic 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 spite of the sudden and dramatic economic downturn that has severely limited the resources available to respond.

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, 95–100 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.

Environment Canada has also announced that it will regulate heavy-duty vehicles in alignment with the upcoming U.S. federal heavy-duty vehicle GHG regulations slated to begin with the 2014 model year. Also coincident with the U.S., Environment Canada published a Notice of Intent to regulate passenger automobiles and light trucks in the 2017–2025 model years.

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 middle distillate fuels.

# Asia Pacific Policy

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

The Chinese Ministry of Industry and Information Technology (MIIT) released the Stage III fuel consumption Monitoring & Reporting rule and began implementing it July 1, 2012. We are now in the monitoring period, which will last from 2012 to 2015. During this phase-in period, the ratio of the Corporate Average Fuel Consumption to the Target Corporate Average Fuel Consumption of all automakers must decline from 109 percent of the target in 2012 to 100 percent in 2015. The China Automotive Technology and Research Center (CATARC) is developing Stage IV fuel-consumption targets, which are expected to be completed in 2014.

The Chinese government provides limited incentives for the purchase of "new energy vehicles" (including plug-in electric vehicles) made by Chinese manufacturers for fleets under local government control. The program currently applies to vehicles in 25 cities. Diesel use is discouraged in passenger car applications in the near term, due to fuel availability concerns. The Chinese government also provides incentives of RMB60K (˜$9700) per vehicle to customers who purchase plug-in or pure electric vehicle models approved as new energy vehicles in Beijing, Shanghai, Changchun, Shenzhen, Hangzhou and Hefei.

Japan, South Korea and Taiwan have released new or modified fuel-economy limits, while Hong Kong, South Korea and Taiwan have linked tax incentives to fuel economy and carbon dioxide targets.

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

# South American Policy

In Brazil, our largest South American market, the 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 designed to accommodate varying amounts of ethanol. 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, as well as a minimum 12 percent improvement in industry-wide fuel efficiency for 2017 light-duty vehicles with a spark-ignition engine, in order to qualify for industrialized products tax reduction. 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.

In 2012, most of Ford's light-duty products in Brazil were offered as ethanol flexible-fuel vehicles. The most recent vehicle line to offer this was the Ford Ranger, which now comes in a 2.5L ethanol flexible-fuel version. Some imported vehicle lines, including the 2013 Ford Fusion, will also come in a flexible-fuel version in Brazil. We also provide light- and heavy-duty vehicles that meet biodiesel requirements.

Other South American countries, such as Argentina and Colombia, are also significantly increasing the use of biofuels. And, 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 beginning in February 2013.

# 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 a leader 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 establishes 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, ethanol has an octane rating greater than today's gasoline, so when the fuels are mixed, the resulting fuel blend will have higher octane than base gasoline. Typically, as the octane rating of a fuel increases, it reduces the tendency for "engine knock," a condition that can, over time, lead to engine damage. (Today, however, while nearly all gasoline offered for sale to our vehicle owners at retail refueling stations across the U.S. is E10, this E10 has been reformulated so the benefits of increased octane rating from ethanol are no longer present.) Many of today's advanced engines currently on the road are programmed to improve the efficiency of the engine just short of the point where the consumer would experience engine knock. For such engines, an increase in the octane rating of the fuel would result in improved vehicle efficiency. Further improvement to engine efficiency (through increased compression ratio and downsizing) could be achieved if manufacturers knew the octane rating of the fuel would be increased and made available to our customers across the nation.

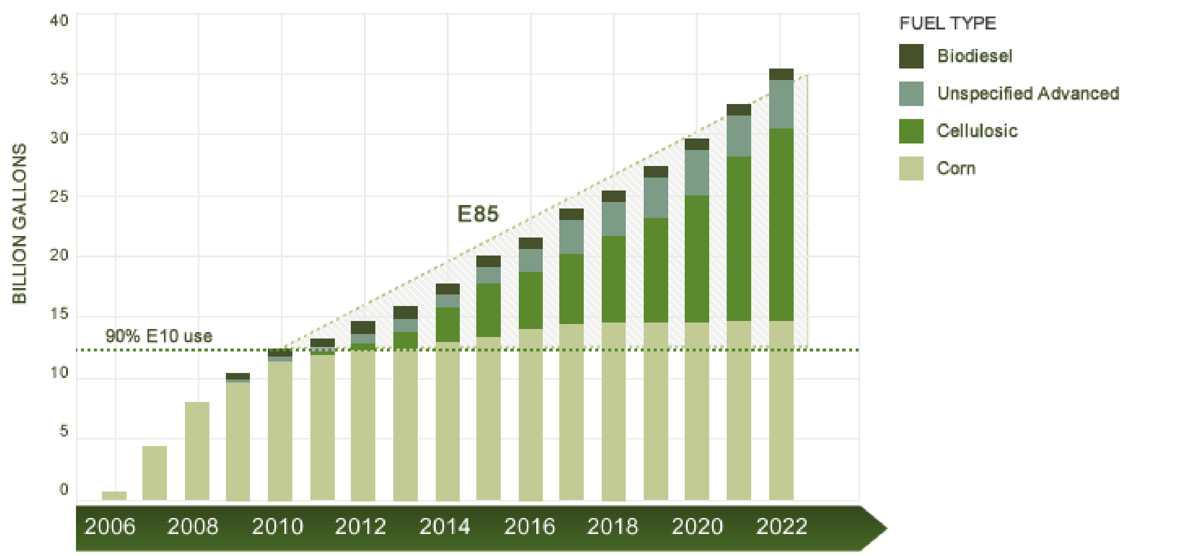
On the other hand, the implementation of the EPA's E15 waiver presents a number of concerns. In particular, Ford is concerned about the impact the waiver will have on the legacy fleet – the millions of vehicles still on the road that were designed to operate on E10 (or E0 for very old vehicles).

Although E15 is not approved for use in such vehicles, there is a need to develop a robust program of regulation to prevent the “misfueling” of these vehicles. Without such a program, we anticipate a high incidence of misfueling, i.e., customers putting E15 fuel in vehicles not designed to use it. We are concerned that such vehicles will not continue to meet customer expectations for quality, durability and performance, as well as legal requirements to meet emission and on-board diagnostic regulations.

Because of these concerns, we believe that the risks for automakers, fuel providers and consumers need to be mitigated and addressed before proceeding with the widespread use of E15. The automobile industry has joined with other industries seeking to overturn the E15 waiver in federal court. We have suggested that the EPA and other policy makers develop a revised, prospective plan for the introduction of E15, in a way that better ensures the fuel is only used in vehicles designed to accommodate it.

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 lifecycle 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
- 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

## Partnerships with Government

We are also engaging in partnerships with federal and state governments in the U.S. to deliver more fuel-efficient vehicles and alternative powertrain technologies. For example, working in close partnership with the state of Michigan, Ford received incentives and tax credits totaling $188 million to help in the continuous transformation of the Michigan Assembly Plant (MAP). These incentives enabled Ford to bring advanced lithium-ion battery system design, development and assembly in-house, as well as build the next-generation hybrid in Michigan.

Ford also received a $2 million grant from the state of Michigan to install a large, stationary battery-based energy storage facility with 750 kW capacity and 2 MWh of storage. This facility supports the state's "smart-grid" development initiatives as well as Ford's efforts to develop battery technology and secondary uses for vehicle batteries. As part of this facility, Ford is demonstrating the possibility for using vehicle batteries as stationary power storage devices after their useful life as vehicle power sources is over. Ford is participating in this project in partnership with DTE Energy, a Michigan-based energy provider. DTE Energy has installed a 500 kW solar photovoltaic (PV) electricity generation system at the demonstration facility, which will produce some of the energy to be stored in Ford's stationary battery storage facility. It is the largest PV array in Michigan. The solar PV system was funded by DTE Energy to support Ford's sustainability efforts and to help the state of Michigan meet its renewable energy production requirements. As part of this project, Ford developed 10 electric vehicle charging stations, which demonstrate advanced battery charging technologies and associated integration with renewable energy and other smart-grid advances.

# 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 five 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 CCX, we built a world-class $CO_2$ tracking infrastructure for our facility emissions. We will continue to leverage this system to support voluntary reporting globally, to measure progress against our new facility $CO_2$ target, and to ensure compliance with the EU trading 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, Argentina, Australia, Brazil, China, the Philippines and Taiwan. 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 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.
- 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

# Sustainable Technologies and Alternative Fuels Plan

IN THIS SECTION

## Overview of Our Plan

We are making steady progress on our plan to meet our science-based climate stabilization goal, by significantly improving 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 developing sustainable technologies and alternative fuel options. Our goal is 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

This section outlines our plans for improving the fuel economy of vehicles with traditional gasoline and diesel powertrains. These plans include implementing advanced engine and transmission technologies as well as improving aerodynamics and reducing weight.

## Migration to Alternative Fuels and Powertrains

Our migration to alternative fuels and powertrains includes introducing electrified vehicles – i.e., hybrids, plug-in hybrids and all-electric vehicles – as well as implementing 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 have completed the near-term actions embodied in this plan and are currently implementing the mid-term actions.

✔ indicates action completed

| In Place | Near Term | Mid Term | Long Term |
|---|---|---|---|
| Fundamental technologies in place | Fully implement fundamental technologies; introduce significant weight savings | Expand weight savings, hybrids and plug-ins | Leverage hybrids and introduce alternative energy sources |
| ✔ Significant number of vehicles with EcoBoost® engines<br>✔ Diesel use as market demands<br>✔ Electric power-assisted steering – begin global migration<br>✔ Battery Management Systems – begin global migration<br>✔ Aerodynamics improvements<br>✔ Dual-clutch and six-speed automatic transmissions replace four- and five-speeds<br>✔ Increased unibody applications<br>✔ Introduction of additional small vehicles<br>✔ Auto start-stop systems (micro-hybrids) introduced<br>✔ Add hybrid electric vehicle (HEV) applications<br>✔ Flexible-fuel vehicles<br>✔ Compressed natural gas (CNG) prepped engines available where select markets demand | • EcoBoost engines available in nearly all vehicles; engine displacement reduction aligned with vehicle weight savings<br>✔ Electric power-assisted steering – high volume<br>✔ Additional aerodynamics improvements<br>✔ Six-speed automatic transmissions – high volume<br>• Introduce substantial weight reductions; 250–750 lbs.<br>✔ Increased application of Auto Start-Stop<br>✔ Increased use of hybrid technologies<br>✔ Introduction of plug-in hybrid electric vehicle (PHEV) and battery electric vehicle (BEV)<br>✔ Vehicle and powertrain capability to leverage available renewable fuels<br>• Develop fuel cell stack technology | • Introduce second-generation EcoBoost and advanced tech diesel<br>• Efficient heating, ventilation and air conditioning for HEVs, PEHVs and BEVs<br>• High-volume eight-plus speed automatic transmissions<br>• Continued weight reduction actions via advanced materials<br>• Increase volume of HEV and PHEV technologies<br>• Evolve BEV and PHEV ecosystems<br>• Optimize engines/vehicles for higher octane/alternative fuels<br>• Introduction of fuel cell electric vehicles | • Second-generation EcoBoost and advanced tech diesels – high volume<br>• Continued efficiencies in electrical architecture and intelligent energy management<br>• Lightweight materials proliferate to global platforms<br>• Next-generation HEV and PHEV technologies<br>• Continued leverage of BEVs<br>• Engines capable of operating on fuels with increased renewable hydrocarbons<br>• 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.

We also 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.

Most importantly, 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 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 next-generation hybrid electric Ford C-MAX, and the C-MAX Energi plug-in hybrid – all built on our global C-platform.

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. 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, are all available 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 lifecycle 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.

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.

# Improving Fuel Economy


This section outlines our plans for improving the fuel economy of traditional gas and diesel engines. These actions include implementing advanced engine and transmission technologies, weight reductions and aerodynamic improvements, as well as increasing the efficiency of 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 affordability relative to competing powertrain options, and 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 sold more than 520,000 EcoBoost-equipped vehicles globally. In 2012 we offered 11 EcoBoost-equipped vehicles in the U.S., up from seven in 2011, thereby tripling the production capacity of EcoBoost-equipped Ford vehicles. By the end of 2013 we will offer EcoBoost engines on four more North American nameplates; at that point they will be available on 90 percent of our North American and European nameplates. Also, we continue to migrate EcoBoost engines to our other regions.

All told, we have introduced or announced five 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.

- 2.0L 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 was introduced on the 2013 Ford Escape. It is also available on the 2013 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 will be introduced first in China in the all-new Ford Mondeo, with applications following in the Fusion sedan in North America and the new 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 are migrating this engine into the B-MAX, C-MAX and all-new Mondeo.
  - In the U.S., we are introducing 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, and we ultimately expect to produce up to 1.3 million units annually.

These EcoBoost engines illustrate Ford's plans to use smaller-displacement, power-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 six-speed transmissions across our product portfolio, replacing less-efficient four- and five-speed transmissions. We are also improving the performance of all our advanced transmissions by further optimizing their operation with EcoBoost engines and further reducing parasitic losses such as mechanical friction and extraneous hydraulic and fluid pumping, to achieve higher operating efficiency. We are also researching other advanced transmission concepts to support further efficiency improvements. In April 2013, for example, 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, which will provide further vehicle performance and fuel-efficiency benefits.

### Benefits

Six-speed transmissions improve fuel economy by up to 9 percent over four- and five-speed gear boxes, depending on the application. They also provide better acceleration, smoother shifting and a quieter driving experience.

### Deployment

We have already introduced six-speed transmissions in the majority of our vehicles. Ninety-eight percent of the transmissions on our vehicles in North America are now advanced six-speed gearboxes. We plan to make advanced eight-plus speed gearboxes available by the end of the decade.

## Electric Power-Assisted Steering

### Technology Overview

Electric power-assisted steering (EPAS) uses a small electric motor instead of conventional hydraulic systems to control 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 3–4 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. 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 new 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

Start-stop technology is already being used in our hybrid vehicles and will eventually provide a cost-effective way to improve fuel efficiency on a large volume of non-hybrid vehicles. In the U.S., we introduced the technology on the all-new 2013 Ford Fusion with 1.6L engine and automatic transmissions. 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.

Unibody vehicle designs reduce weight by eliminating the need for the body-on-frame design used in truck-based products. We are also 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 re-matching 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

Unibody designs have replaced heavier truck-based designs on the Ford Explorer, Ford Edge and Lincoln MKX crossover.

And we have implemented lighter-weight materials in a range of vehicles and parts applications, including the following:

- 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 vs. solid injection molding, and molding cycle time is reduced 15 percent. This plastic was the Grand Award Winner at the 2011 Society of Plastic 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.

- We use an aluminum hood on the Ford F-150 and high-strength, lighter-weight steels in more than 50 percent of the F-150 cab.

- 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 to further reduce weight. 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 in Europe on the Ford Focus and Mondeo and in the U.S. beginning with the 2011 Ford Edge, Explorer and F-150, the 2011 Lincoln MKX and the 2012 Ford Focus. We will continue to implement BMSs on a range of 2013 model year vehicles. 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 shut-off to lower speeds and more types of common driving conditions, without compromising driving performance or emissions.

### Benefits

This improved fuel shut-off 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.

## Aerodynamics

## Technology Overview and Benefits

We are optimizing vehicle aerodynamics to improve the fuel economy of our global product lineup. Using a systems engineering approach that integrates aerodynamics in an interdisciplinary and collaborative design and development process with other fuel-economy technologies, we are maximizing the fuel efficiency of every vehicle we develop. During the development process, we use advanced computer simulations and optimization methods coupled with wind-tunnel testing to create vehicle designs that deliver up to 5 percent better fuel economy. In addition, we are developing simulation systems that allow us to replicate on-the-road driving conditions during the virtual design phase, to facilitate the real-world benefits of aerodynamic improvements. We have a global aerodynamics team to support global product design. Aerodynamics engineers from North America, Europe, South America and Asia Pacific and Africa collaborated to deliver three of our most important global vehicles – the 2013 Ford EcoSport, C-MAX and Ranger pickup – with improved aerodynamics.

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 Grill 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.

We are also making significant improvements in aerodynamics on vehicles introduced for the 2012 to 2014 model years. For example:

- We reduced aerodynamic drag in the 2013 Fusion and Lincoln MKZ up to 10 percent, in comparison with the 2012 models, through extensive aerodynamic improvements, including underbody shielding, tire spoilers, wheels, body shape, vehicle proportion and Active Grille Shutters. Our aerodynamics engineers even optimized the aerodynamics of wheel and mirror design to further reduce drag from the front of the vehicle. The 2013 Fusion Hybrid achieved an outstanding drag coefficient of as low as 0.27 – among the best in the world. (For more information on our fuel-economy leaders, please see Vehicle Fuel Economy and $CO_2$ Emissions Progress and Performance.)
- The 2013 Ford Escape is nearly 10 percent more aerodynamic than the outgoing model.
- We significantly reduced the drag coefficient on the all-new 2012 Focus four-door to 0.297 from the previous model's 0.320. Optimized aerodynamics also help to reduce wind noise in the Focus.

# 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 are introducing subcompact vehicles commonly referred to as "B-cars." These include the all-new Ford Fiesta, which was introduced in Europe in 2008, the Asia Pacific region in 2009 and the Americas in 2010.
- 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. In 2011, we launched the next-generation global Ford Focus to North America. This vehicle includes the first in a series of powertrain technology developments that will give our C-car segment offerings a combination of power, performance and unsurpassed fuel economy. We also now offer a battery-electric version called the Focus Electric. In addition, we introduced the C-MAX Hybrid and C-MAX Energi, a plug-in hybrid, in the U.S. The C-MAX is a multi-activity vehicle based on our C-platform. And, we brought the European Transit Connect small commercial van to 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.

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# Migration to Alternative Fuels and Powertrains

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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 above.

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## Advanced Clean Diesel

Ford's New Full-Size Transit Van

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 introduced a new 3.2L Power Stroke® turbo diesel engine in our full-size Transit van, following up on the launch of a new 6.7L V8 Power Stroke turbo diesel in the 2011 F-Series Super Duty® truck, which had 20 percent better fuel economy than the outgoing model.

## 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 6.7L Power Stroke V8 diesel, offered on Super Duty Trucks in the U.S., which has 20 percent better fuel economy and 14 percent more power than the previous model, uses an innovative exhaust gas recirculation system with two independent cooling loops, which enable optimal combustion phasing for fuel economy while reducing NOx emissions from the engine into the after-treatment system. It also uses a high-precision, common-rail fuel-injection system featuring piezo-electric injectors. This system uses a stack of more than 300 wafer-thin ceramic platelets to control the fuel-injector nozzle, allowing it to operate faster than other electro-mechanical fuel injectors, decrease fuel consumption and reduce emissions.

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.

## 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/100km and emits just 89 g/km of $CO_2$.

In North America, where diesels engines are primarily used in the medium-duty truck market, Ford offers two advanced diesel engines. In 2012, we introduced 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 also meet the U.S. Environmental Protection Agency's and California Air Resources Board's strict 2010 heavy-duty truck emission regulations, which require 80 percent lower NOx emissions than the 2007 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 also expected to be 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 lifecycle $CO_2$ 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)

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## 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.

Our past HEVs used nickel metal hydride batteries. The HEVs we are launching now 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
- 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 the fall of 2012, we launched our newest HEV, the all-new C-MAX Hybrid. This is one of three electrified vehicle options on our C-platform; the others are the Focus Electric BEV and the C-MAX Energi PHEV. The C-MAX Hybrid uses Ford’s powersplit hybrid architecture, with improved fuel efficiency and a lighter, smaller lithium ion battery system.

With the launch of the C-MAX Hybrid and C-MAX Energi, Ford becomes North America’s largest maker of hybrid transmissions.

Also in 2012, we launched a hybrid version of the newly redesigned Ford Fusion. 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. The new Fusion Hybrid features an all-new 2.0L Atkinson-cycle four-cylinder gasoline engine, which is significantly downsized from the previous 2.5L unit while maintaining performance standards. This innovative powertrain delivers fuel economy of 47 mpg in city and highway driving. We also continue to offer a hybrid electric version of the Lincoln MKZ.

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# Battery Electric Vehicles (BEVs)

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## Battery Electric Vehicles (BEVs)

Ford Focus Electric

Electric vehicles use no gasoline; they are powered by a high-voltage electric motor and battery pack. In 2012, Ford launched the Focus Electric, with 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 a four-hour charge time 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 onboard 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 initially introduced the Focus Electric in 19 U.S. metropolitan areas. We are now expanding availability to new markets and ramping up to higher volumes.

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# Plug-in Hybrid Electric Vehicles (PHEVs)

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### 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 introduced its first commercially available PHEV, the C-MAX Energi, in the U.S. in 2012.

## 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 lifecycle 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
- Potential consumer savings on energy and fuel costs

- 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

In 2012 we introduced the Ford C-MAX Energi in the U.S., our first production PHEV. The C-MAX Energi has a U.S. Environmental Protection Agency (EPA)-rated combined fuel economy of 100 MPGe, plus a 620-mile overall driving range. In January 2012, we introduced the Ford Fusion Energi, a plug-in hybrid version of our all-new Fusion. The Fusion Energi also delivers 100 MPGe.

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 Collaborating with Partners in our Electrification section.

# Renewable Biofueled Vehicles

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## 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.

## Current Generation Biofuels

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.

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.

Given the current trends of increasing biofuel production, increasing investment in advanced biofuels, increasing vehicle efficiencies and the introduction of vehicles that do not use liquid fuels (such as electric and natural gas vehicles), we believe that the use of biofuels may increase from a current level of approximately 2–3 percent globally to 10–30 percent of global liquid road-transportation fuel over the next few decades. Although Ford is a vehicle manufacturer and not a fuel provider, it is important for us to understand the physical and chemical properties of biofuels (such as their octane ratings), their sustainability attributes (such as lifecycle greenhouse gas (GHG) emissions, water use and energy consumption) and their performance in our vehicles. We are conducting research and development to ensure that our vehicles will be able to exploit the full benefits of biofuels. Our current work focuses on the two biofuels that are available at a commercial scale: ethanol and biodiesel.

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 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 is also used in Brazil; it is mixed with little or no gasoline.) 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, while E85 is up to 85 percent by volume ethanol. 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 a separate section below.

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 are developing a new fundamental molecular approach to calculating the octane increase provided by ethanol blended into gasoline, which is more accurate than previous approaches.[1,2], 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.[3]

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 calculations will help us take the best advantage of higher-octane ethanol-fuel blends 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." 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., our 2012 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 flexiblefuel compatible with gasoline, E85 or any ethanol-gasoline blend between E0 and E85.

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.

## E15 in the United States

In 2012, the U.S. EPA approved the use of E15 ethanol blends in 2001 and newer model year vehicles. While Ford supports the use of renewable fuels to meet the challenges of energy security and climate change and has committed to expand our lineup of vehicles capable of operating on E85, we do not support approving the use of E15 in older vehicles that were never designed to be operated on that fuel.

The entire legacy fleet of non-FFVs in the U.S. consists of vehicles designed to operate on E0 to E10 (or only E0 for very old vehicles). We are concerned that vehicles will not continue to meet customer expectations for quality, durability and performance, or legal requirements relating to emissions and onboard diagnostics, if the vehicles are operated on a fuel they were not designed to use. The Alliance of Automobile Manufacturers and the Association of International Automobile Manufacturers are among many parties seeking judicial review of the E15 waiver. Ford is a member of the Alliance. Our goal is to ensure that the current and future fuel supply in the U.S. will enable our vehicles to operate properly without creating problems for our customers. We will continue to work with our customers and dealerships in an effort to prevent or mitigate any such problems.

We are undertaking appropriate testing and modifications to allow all of our vehicles in the U.S. from the 2013 model year forward to operate on E15 without affecting the warranty. One opportunity with the introduction of increased ethanol blends is to increase the octane rating of the new fuel. As discussed above, ethanol has an octane rating greater than today's gasoline, so when the fuels are mixed, the resulting fuel blend should have a higher octane rating than the base gasoline. As the octane rating of a fuel increases, it reduces the tendency for "engine knock." Many of today's advanced engines are programmed to improve the efficiency of the engine just short of the point where the consumer would experience engine knock. For such engines, an increase in the octane rating of the fuel could result in improved vehicle efficiency. Further improvement to engine efficiency (through increased compression ratio and downsizing) could be achieved if manufacturers knew how and when the minimum octane ratings of fuels would increase in the future. Given that a vehicle's efficiency and performance depends on the fuel it uses, the two should be considered systematically. Coordinated efforts among the involved industries (oil, biofuel, auto) and regulatory agencies are needed to ensure that maximum benefit is gained from our future fuels and vehicles.

## 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 lifetime (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. We are also investigating the potential for algae-based biofuels to provide another feedstock for future biofuels. Given the challenges associated with developing and scaling up new production technologies, it is our assessment that next-generation biofuels will be available at scale in the marketplace in the next 10–15 years, if the necessary technical breakthroughs in production efficiencies are made and if the investment climate is sufficiently favorable to encourage large capital outlays required to build the biorefineries.

## 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 nearly 20 percent of U.S. gasoline demand by 2022.[4] 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 and because a relatively small percentage of light-duty passenger vehicles in the U.S. use diesel.

Full deployment of E10 for gasoline-powered vehicles would achieve approximately 40 percent 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 blends would require that all new vehicles be designed for higher ethanol capability, and the existing fueling infrastructure would need to be made compatible 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 the 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 2,600 (or less than 2 percent) offer E85. This trails the availability of E85 vehicles in the marketplace. Approximately 5.5 percent of the U.S. light-duty vehicle fleet is FFVs, a figure that is increasing because FFVs now account for nearly 20 percent of all new light-duty vehicles being produced. For consumers to have a true transportation fuel choice, increased access to biofuels 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 to achieve their full theoretical potential.

Challenges relating to today's biofuels include the following:

- Energy Density: The energy density of ethanol is approximately two-thirds that of gasoline.[5] 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.[6] 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 lifecycle 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 lifecycle 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, perhaps by up to 90 percent.[7]

- 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 distillers' 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 10–15 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). This is a complex and important issue. Converting natural lands to croplands can lead to the release of carbon stored in above- and below-ground biomass. Releasing this carbon in the form of $CO_2$ during land conversion to farming creates a carbon "debt," which may take a very long time to repay through the greenhouse gas benefits of the subsequent biofuel use. The use of degraded pastures or abandoned farmland, by contrast, rather than natural ecosystems, would incur minimal carbon debt, because there is limited $CO_2$ storage in these previously altered ecosystems.

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.

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**Climate Change and the Environment**

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# CNG/LPG Vehicles

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## CNG/LPG Vehicles

Ford Super Duty 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 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 running these types of fuel have lower carbon dioxide ($CO_2$) emissions and lower total greenhouse gas (GHG) emissions than gasoline or diesel vehicles. When running on CNG, our vehicles typically emit 19–21 percent less $CO_2$ and 26–29 percent fewer total GHGs, according to our own internal tests. LPG-fueled F-series trucks typically emit 17–24 percent fewer total lifecycle 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. CNG costs range from $1.08 to $2.40 per gallon on a gasoline gallon equivalent basis, resulting in up to a 73 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. 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. 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 onsite assessments at each QVM location to ensure conformance to a high standard of manufacturing, assembly, workmanship and customer service. We currently work with six QVM suppliers for CNG conversions (Altech-Eco, BAF, 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:

- Transit Connect, 2.0L (CNG only)
- 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
- F53 & F59 Stripped Chassis, 6.8L

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

- The all-new Ford Transit range of full-size vans, wagons, cutaways and chassis cab models with a 3.7L engine
- The next-generation Transit Connect lineup with a new 2.5L engine
- The 2014 Lincoln MKT Town Car Limousine and Livery packages with 3.7L engines
- Future F-150 trucks

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.

# Hydrogen Fuel Cell Vehicles (FCVs)

**IN THIS SECTION**


Advanced Clean Diesel


HEVs


BEVs


PHEVs


Renewable Biofueled Vehicles


CNG/LPG Vehicles


FCVs

## 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. In January 2013 we announced a partnership with Daimler AG and Nissan Motor Co., Ltd. to develop fuel cell vehicle technology that could result in a production vehicle as early as 2017.

## 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.

Onboard 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 onboard 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 ($H_2$ICEs). 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.

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# Vehicle Fuel Efficiency and $CO_2$ Emissions Progress and Performance

Vehicle + Fuel + Driver = GHG Emissions

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. Lifecycle analyses have found that 80 to 90 percent of vehicle-related GHGs are emitted during the use phase. 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.

But use-phase vehicle emissions are also dependent on the “well-to-wheels” greenhouse gas profile of the fuels used in the vehicles and how the vehicles are used and maintained by their drivers. Therefore, we also report on fuels-related GHG emissions, including electrification and biofuels, and 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

Vehicle + Fuel + Driver = GHG Emissions



## 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 example, 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. By the end of 2012, we delivered 50 of the 62 planned new or significantly updated powertrains to help us improve fuel economy and reduce carbon dioxide emissions across our global fleet.

EcoBoost® engines, which use gasoline turbocharged direct-injection technology, are the centerpiece 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. At year-end 2012, we had produced more than 520,000 EcoBoost engines. By the end of 2013, we will offer EcoBoost engines on 90 percent of our North American and European nameplates, and we continue to migrate them to our other regions. For more information on EcoBoost and our other near-, mid- and long-term fuel-economy improvement technologies, please see our Sustainable Technologies and Alternative Fuels Plan.

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## Results

We continue to improve the fuel economy of our new and refreshed vehicles in each of our markets worldwide. 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. For example, we recently launched our new 1.5L EcoBoost engine, which will be built in Romania and first introduced in the Ford Mondeo sold in China. As discussed above, EcoBoost significantly improves fuel efficiency and reduces emissions; by the end of this year, 80 percent of the Company's global nameplates will be available with this fuel-saving technology. In 2013, the 3.2L Power Stroke® Diesel engine will be introduced 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.

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. In addition to EcoBoost engines, for example, we now offer a wide range of fuel-efficient technologies on our conventionally fueled vehicles, including advanced transmissions and Automatic Start-Stop. We also offer six new electrified products in North America, natural gas- and propane-ready engines, and vehicles that can operate on higher blends of biofuels. 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 every all-new or redesigned vehicle we introduce will be best in class for fuel economy or among the leaders in its segment. For more information on our overall approach to fuel-efficient and alternative powertrain technologies, please see our Sustainable Technologies and Alternative Fuels Plan.

For the 2012 model year, our U.S. fleet $CO_2$ emissions decreased by about 7 percent relative to the 2011 model year and improved 15 percent compared to the 2007 model year. Preliminary data for the 2013 model year project that the Corporate Average Fuel Economy (CAFE) values will improve for both our car and truck fleets, compared to the 2012 model year. In Europe, preliminary data show that we have reduced the average $CO_2$ emissions of our car fleet by 15.5 percent between the 2007 and 2012 calendar years.[1]

The following are some examples of our fuel-efficient vehicles 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. Among those with class-leading fuel economy, for example, are the 2013 Ford Fusion, Escape, and Taurus with the 2.0L engine, as well as the Lincoln MKZ. With the introduction of these new vehicles, we now have the most fuel-efficient vehicle lineup in our Company’s history.

For the 2013 model year, we offer eight vehicles that get 40 mpg (or MPGe) or better:

- Ford Fiesta SFE
- Ford Focus SFE
- Ford Focus Electric
- Ford Fusion Hybrid
- Ford Fusion Energi
- Ford C-MAX Hybrid
- Ford C-MAX Energi
- Lincoln MKZ Hybrid

In addition to the above, we are offering eight 2013 model year nameplates with 12 powertrain variations that get 30 mpg or better:

- Ford Fiesta 1.6L
- Ford Focus 2.0L
- Ford Fusion 1.6L
- Ford Fusion 2.0L
- Ford Fusion 2.5L
- Ford Taurus 2.0L
- Ford Edge 2.0L
- Ford Escape 1.6L
- Ford Escape 2.0L
- Ford Escape 2.5L
- Ford Mustang 3.7L
- Lincoln MKZ 2.0L

We also continued to expand the use of our EcoBoost engines, which significantly improve the fuel economy of gasoline engines. We will equip as much as 90 percent of our North American and European nameplates with EcoBoost engines by the end of 2013.

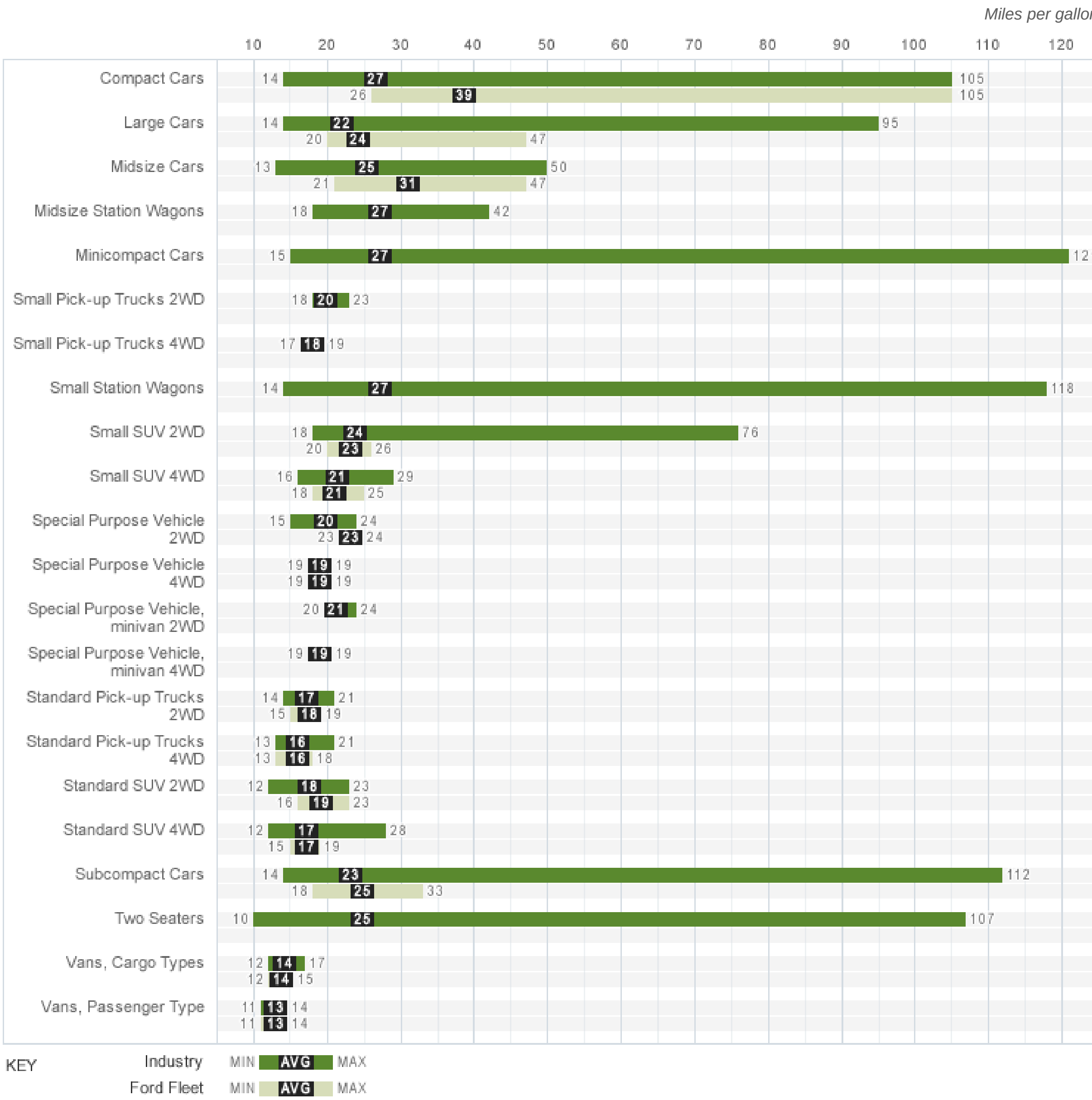
As illustrated in the graphics below, we have made significant progress in improving the fuel economy of, and hence reducing the $CO_2$ emissions from, our vehicles in North America. Figure 1 illustrates the improvement in fuel economy of key Ford vehicle models from 2003 to 2013. Figure 2 illustrates how the fuel economy of Ford vehicles compares to industry averages by vehicle segment for the 2013 model year. Ford's 2013 model year U.S. vehicles rank better than the industry fuel-economy average in seven of 14 categories, the same in six, and worse in one.

## Figure 1: Nameplate fuel economy improvement summary

| | 2003 MY | 2013 MY | % FE Improvement (Unadjusted Combined) |
|---|---|---|---|
| FOCUS |  |  | 24.2[1] |
| ESCAPE |  |  | 25.8 |
| EXPLORER |  |  | 30.9[2] |
| F-150 |  |  | 15.8[3] |

1. Wagon excluded, BEV excluded.
2. Explorer Sport, Sport Trac and ethanol-fueled flexible-fueled vehicles (FFVs) excluded.
3. Ethanol-fueled FFVs, natural gas vehicles and SVT Raptor excluded.

## Figure 2: Fuel economy of U.S. Ford vehicles by segment




| | Industry | | | Ford | | |
|---|---|---|---|---|---|---|
| | Minimum | Average | Maximum | Minimum | Average | Maximum |
| Compact Cars | 14 | 27 | 105 | 26 | 39 | 105 |
| Large Cars | 14 | 22 | 95 | 20 | 24 | 47 |
| Midsize Cars | 13 | 25 | 50 | 21 | 31 | 47 |
| Midsize Station Wagons | 18 | 27 | 42 | | | |
| Minicompact Cars | 15 | 27 | 121 | | | |
| Small Pick-up Trucks 2WD | 18 | 20 | 23 | | | |
| Small Pick-up Trucks 4WD | 17 | 18 | 19 | | | |
| Small Station Wagons | 14 | 27 | 118 | | | |
| Small SUV 2WD | 18 | 24 | 76 | 20 | 23 | 26 |
| Small SUV 4WD | 16 | 21 | 29 | 18 | 21 | 25 |
| Special Purpose Vehicle 2WD | 15 | 20 | 24 | 23 | 23 | 24 |
| Special Purpose Vehicle 4WD | 19 | 19 | 19 | 19 | 19 | 19 |
| Special Purpose Vehicle, minivan 2WD | 20 | 21 | 24 | | | |
| Special Purpose Vehicle, minivan 4WD | 19 | 19 | 19 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Standard Pick-up Trucks 2WD | 14 | 17 | 21 | 15 | 18 | 19 |
| Standard Pick-up Trucks 4WD | 13 | 16 | 21 | 13 | 16 | 18 |
| Standard SUV 2WD | 12 | 18 | 23 | 16 | 19 | 23 |
| Standard SUV 4WD | 12 | 17 | 28 | 15 | 17 | 19 |
| Subcompact Cars | 14 | 23 | 112 | 18 | 25 | 33 |
| Two Seaters | 10 | 25 | 107 | | | |
| Vans, Cargo Types | 12 | 14 | 17 | 12 | 14 | 15 |
| Vans, Passenger Type | 11 | 13 | 14 | 11 | 13 | 14 |
| Total | 10 | 23 | 121 | 11 | 23 | 105 |

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## Europe

Ford already offers one of the broadest low-$CO_2$ vehicle portfolios in Europe. In 2008, we began launching our ECOnetic Technology line of vehicles. These ultra-low-$CO_2$ versions of select Ford diesel vehicles 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. The expansion of ECOnetic Technology to a wider range of models is part of Ford’s overall sustainability strategy, including the target of reducing $CO_2$ emissions of our cars by 30 percent between 2006 and 2020. In addition to these low-$CO_2$ models, in 2012 we also introduced the new 1.0L EcoBoost engine. This downsized engine – as well as other fuel-saving technologies such as Automatic Start-Stop, Smart Regenerative Charging, Active Grille Shutter, and EcoMode – are available on the Ford Fiesta, C-MAX, Grand C-MAX, Focus, Mondeo, S-MAX and Galaxy. Ford is the only non-premium manufacturer currently offering Active Grille Shutter.

In 2012, we extended the availability of best-in-class, or among-best-in-class, extremely low-$CO_2$ vehicles, which now include the following:

- The new Fiesta, launched in November 2012, delivers best-in-class fuel economy with a 1.0L EcoBoost engine that achieves 4.3L/100 km and 99 kg/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 km[2] (86 mpg UK[3]/71 mpg U.S.) and $CO_2$ emissions of 87 g/km. The new model showcases technology innovations such as Automatic 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, undershield and wheel deflectors, as well as low-rolling-resistance tires, are used to further reduce driving resistances.
- The new Focus ECOnetic delivers fuel economy of 3.4L/100 km[4] (83.1 mpg UK[5]/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. It is uniquely equipped with a lean NOx trap in combination with a coated diesel particulate filter.
- The Mondeo ECOnetic has a specially calibrated 115PS (85 kW) version of the 1.6L Duratorq TDCi engine equipped with a standard catalyzed diesel particulate filter. Due to a combination of changes compared to the standard Mondeo, the second-generation Mondeo ECOnetic is delivering a combined fuel consumption of just 4.3L/100 km[6] (65.6 mpg UK[7]), which translates into average $CO_2$ emissions of 114 g/km – an important tax break point in some European markets.
- 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[8] (58.9 mpg UK[9]/49 mpg U.S.) and $CO_2$ emissions of 109 g/km. The 125PS model returns 5.0L/100 km[10] (56.5 mpg UK[11]/47 mpg U.S.) with $CO_2$ emissions of 114g/km.

In total, Ford offers 39 models and variants in Europe with $CO_2$ emissions below 130 g/km, of which nine models or variants have $CO_2$ emissions below 100 g/km.

After the successful introduction of the new EcoBoost gasoline engine family in the U.S., Ford launched 2.0L and 1.6L EcoBoost engines in Europe in 2010. These turbocharged, direct-injection gasoline engines will deliver up to 20 percent better fuel economy and fewer $CO_2$ emissions compared to conventional gasoline engines. In February 2012 the all-new 1.0L EcoBoost, first available in the Focus, joined the 1.6L EcoBoost gasoline and 1.6L TDCi ECOnetic in being leaders or among the very best in their segment in terms of fuel economy. The 1.0L EcoBoost is now available in the C-MAX, the all-new B-MAX and the new Fiesta. The engine uses turbocharging and direct fuel injection to extract impressive levels of power and fuel efficiency from its three-cylinder engine block, which is so small it can fit on a sheet of A4 paper. This combination of power and low $CO_2$ emissions is unmatched by competitors in its segment. The engine's high torque of 170 Newton meters between 1,400 rpm and 4,500 rpm (or between 1,400 rpm and 4,000 rpm in the 100PS version) supports a fuel-efficient driving style and delivers a good performance feel and diesel-like torque experience. The 1.0L EcoBoost was named 2012 "International Engine of the Year" based on votes cast by 76 journalists from 35 countries around the world. This marks the first time Ford has won International Engine of the Year in the 13-year history of the awards. Moreover, the 1.0L EcoBoost received the highest score in the history of the awards. The engine also received "Best New Engine" and "Best Engine Under 1.0 Liter" awards from *Engine Technology* magazine.

Our global electric vehicle plan is extending to Europe with the Focus Electric, which will be launched in summer 2013, and other hybrid vehicles will be launched in coming years.

Ford of Europe's innovative Product Sustainability Index (PSI) shows how the vision of sustainability can be made operational. By combining comprehensive sustainability criteria into the earliest stages of the product development process, Ford's PSI provides a groundbreaking design-for sustainability tool. Designers can use it to assess the lifecycle $CO_2$ emissions of a vehicle, and consumers can use it to understand a vehicle's footprint.

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## Asia Pacific and Africa

Ford will upgrade its entire powertrain portfolio in China 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. Ford's joint venture, Changan Ford Automobile Co., Ltd. (CAF), is building a new engine plant and a new transmission plant to speed up the localization of advanced powertrains to meet China's fast-growing demands. We are also continuing efforts to develop products that support the evolving "new energy vehicle" (defined as battery electric and plug-in hybrid electric vehicles) market in China.

We are introducing our fuel-efficient EcoBoost engines across Asia, and they are being well received by our customers. In China, 66 percent of Ford Mondeo vehicles sold in 2012 were equipped with the EcoBoost engine. In June 2012, Ford China launched the Edge with a 2.0L EcoBoost engine, and sales of the Edge with EcoBoost accounted for 99 percent of total Edge sales in China from June to December 2012. In March 2013, the award-winning 1.0L EcoBoost engine made its ASEAN[12] debut in the new Fiesta and EcoSport at the Bangkok International Motor Show. In early April, Ford announced that the first application of the 1.5L EcoBoost engine will be in the new Mondeo in China.

In India, we are also continuing to introduce vehicles with excellent fuel economy. The Fiesta – powered by 1.5L Ti-VCT gasoline and TDCi diesel powertrains developed for India – delivers class-leading fuel economy and reduced $CO_2$ emissions compared to the outgoing model. 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. These vehicles are highly significant to our success in India, as our studies show fuel economy to be the most important criteria in purchase consideration in that country. The EcoSport in India, which we plan to introduce mid-2013, will be powered by the 1.0L EcoBoost engine, making Ford the first manufacturer in the country to launch an SUV with a 1.0L gasoline engine.

In Australia, we launched an EcoBoost version of the Ford Mondeo in 2011 and an EcoBoost Ford Falcon in 2012. EcoBoost is also now available in the Focus ST and will be available in the all-new Kuga in mid-2013. Also in Australia, Ford's next-generation EcoLPi liquid-injection liquefied petroleum gas (LPG) system for the Falcon became available in 2011, 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 using technologies specifically relevant to the widespread use of biofuels in Brazil. In 2011, we introduced the Ford Mondeo with an EcoBoost engine in Argentina, which marked the debut of EcoBoost technology in South America. 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 2012 in Brazil, we launched the new Ford EcoSport, a B-segment SUV, which is a fuel economy leader in its segment. In early 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.

For the 2014 model year and beyond in South America, we are planning to introduce even more fuel-efficient twin independent variable cam timing engines and direct-injection engines, Battery Management Systems, smart alternator systems, dual-clutch automatic transmissions and improved aerodynamics in the B- and C-sized vehicle segments, which make up approximately 80 percent of the Brazilian market.

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1. The final 2012 calendar-year fleet-wide $CO_2$ emissions data for our European fleet will be available in November 2013. For all years, these data do not include Volvo.
2. 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.
3. 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 UK imperial gallon, which is 1.2 times the U.S. gallon.
4. 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.
5. 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. The fuel economy figures in mpg are based on the UK imperial gallon, which is 1.2 times the U.S. gallon.
6. 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.
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. The European standard test drive cycle, NEDC, is used for type approval of fuel economy and $CO_2$ data. The fuel economy figures in mpg are based on the UK imperial gallon, which is 1.2 times the U.S. gallon.
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.
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. The European standard test drive cycle, NEDC, is used for type approval of fuel economy and $CO_2$ data. The fuel economy figures in mpg are based on the UK imperial gallon, which is 1.2 times the U.S. gallon.
10. 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.
11. 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. The fuel economy figures in mpg are based on the UK imperial gallon, which is 1.2 times the U.S. gallon.
12. Association of Southeast Asian Nations

# Fuel

Vehicle + **Fuel** + Driver = GHG Emissions

To reduce lifecycle greenhouse gas (GHG) emissions to the levels required for carbon dioxide ($CO_2$) stabilization requires the development of fuels with lower fossil carbon content.[1] Such fuels could then augment improvements in the fuel economy of our vehicles. In this section, we briefly discuss electrification and biofuels, two alternatives that Ford is currently implementing commercially. For more information on how Ford is developing and implementing alternatively fueled vehicles and powertrains, please see Sustainable Technologies and Alternative Fuels Plan.

## 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.

Please see Electrification: A Closer Look for more on Ford’s approach to electrified vehicles. 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.

## Biofuels

Biofuel use is expanding globally, with bioethanol made from corn, beets or sugar cane substituting for gasoline, and biodiesel derived from plant oils substituting 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.

While current corn-based bioethanol 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] Building a substantial fleet of flexible-fuel vehicles (FFVs) provides a bridge to the widespread use of lower-carbon biofuels in the future.

Ford has a long history of developing vehicles that run on renewable biofuels. We produced the first flexible-fuel vehicle approximately 100 years ago: a Model T capable of running on gasoline or ethanol. We remain committed to biofuels as part of our sustainability strategy. In fact, the use of alternative fuels is a key piece of our blueprint for sustainability to reduce $CO_2$. Consistent with consumer demand, Ford will continue to provide a range of products designed to run on a wide range of ethanol blends. FFVs provide fuel choice to consumers when the fuel is available and are necessary to transition to advanced alternative fuels.

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.

1. Of course, there is not only a need to reduce the fossil carbon content of the fuel itself, but to reduce any fossil-based $CO_2$ emitted during feedstock excavation, fuel production and distribution.
2. *Ethanol: The Complete Lifecycle Picture*, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, March 2007.

# Driver

Vehicle + Fuel + **Driver** = GHG Emissions

Paradoxically, 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 also recently announced a Personalized Fuel Efficiency App Challenge, which will allow software developers 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 debuted on the 2011 Ford Edge and Lincoln MKX crossovers, followed by the 2011 Ford Explorer and 2012 Ford Focus in North America, and it is now available on 10 Ford vehicles for the 2013 model year: 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® with MyFord Touch will be launched in Europe in 2012, initially on the Ford B-MAX.)

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. EcoMode was first presented in the Ford Focus ECOnetic in Europe in 2009 and has since been made available in a wider range of vehicles. 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 new Fiesta, all-new B-MAX, Focus, C-MAX, new Kuga, Mondeo, S-MAX and

Galaxy.

## 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 Associations 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 2012, more than 17,000 German drivers had been “eco-trained” through this program under real-world conditions.

In 2012, Ford accelerated its support for a European project called ECOWILL. This project, which began in 2010 and is planned to last three years, is based on the premise that drivers’ “eco-behavior” has a great potential to reduce $CO_2$ from motoring without making it less “fun to drive.” ECOWILL has two major strategic 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.
- 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.

In early 2012, we held media test drives in conjunction with the ECOWILL project, which convinced European journalists that the eco-driving approach works well on the road. Jointly with trainers from the European Driving School Association, journalists achieved a 22 percent improvement in fuel consumption by applying the eco-driving style. In spring 2012, we also supported the project’s roll-out phase. Free ECOWILL eco-driving trainings were run for 200 visitors at the Leipzig auto show (AMI Leipzig). At this, Germany’s largest auto show, Ford partnered with DVR (the German Road Safety Council) to implement the training.

In Asia Pacific and 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 2012, Ford DSFL in Asia trained licensed drivers in mainland China, India, Indonesia, Taiwan, Thailand, Vietnam, the Philippines and South Africa. Approximately 13,500 drivers were trained in 2012, and we expect to train another 14,000 in 2013. More than 63,000 people have been trained in the Asia Pacific and Africa region since the program began.

# 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. These emissions are regulated in the U.S. by the U.S. Environmental Protection Agency (EPA) under the Clean Air Act as well as by the California Air Resources Board (CARB).



Related links

Vehicle Websites

- Focus Electric
- C-MAX Energi
- Fusion Energi
- Fusion Hybrid
- C-MAX Hybrid
- Lincoln MKZ Hybrid

External Websites

- EPA's Green Vehicle Guide

## U.S.

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 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.

In 2013, the EPA proposed new Tier 3 standards, which are more-stringent motor-vehicle emissions standards for future model years. As part of these proposed new standards, the EPA suggested reductions in the sulfur levels in gasoline, which would improve the performance of existing catalyst technology in gasoline vehicles and result in reductions 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 increasingly stringent warning systems 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 (PZEVs). A PZEV is a vehicle certified to near-zero emissions standards. Strictly speaking, PZEV vehicles are required to:

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

For the 2012 model year, Ford offered the Focus PZEV, as well as hybrid PZEV versions of the Ford Fusion, Lincoln MKZ and Ford Escape. For the 2013 model year, Ford is offering the Focus Electric PZEV, Focus PZEV and Fusion PZEV, as well as plug-in hybrid AT-PZEV versions of the Ford C-MAX and Ford Fusion.

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 may 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 emission 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," have never produced successful outcomes. 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 3-cylinder 1.0-liter EcoBoost engines. 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-adsorbing 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 and will be applied beginning in September 2014. New test procedures on real-world driving 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 standard. 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 emission 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.

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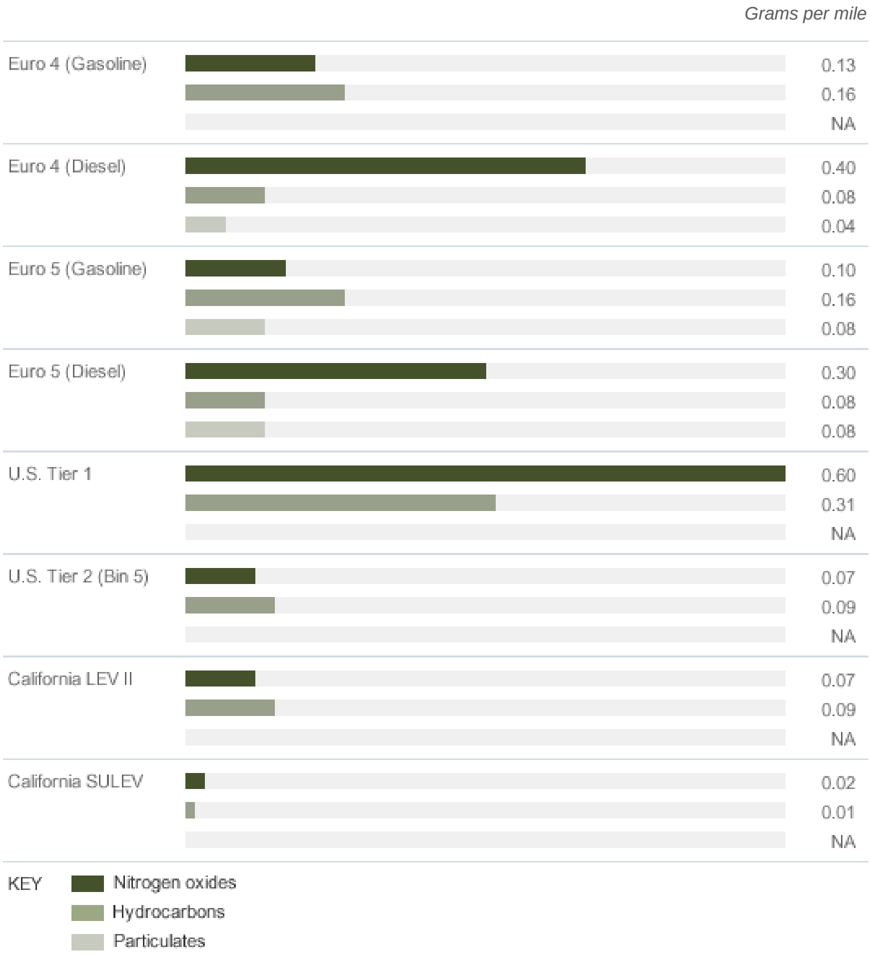
## Emissions Regulations in the U.S. and Europe




| | Nitrogen oxides | Hydrocarbons | Particulates |
|---|---|---|---|
| Euro 4 (Gasoline) | 0.13 | 0.16 | NA |
| Euro 4 (Diesel) | 0.40 | 0.08 | 0.04 |
| Euro 5 (Gasoline) | 0.10 | 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 and Africa

Since 2010, our new gasoline-fueled passenger vehicles have been designed to comply with China Stage IV requirements (based on Euro 4 standards). China plans to implement the most recent European standards (Euro 5) starting in 2013 in large cities. 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 Stage V standards beginning in 2014 (for new vehicle homologations) and 2016 (for new vehicle registrations). Chile approved a plan to introduce more-stringent emission 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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# Sustainable Materials

Materials are an important element of a vehicle's sustainability at all stages of its lifecycle. The selection of materials can influence the safety, fuel economy and performance of the vehicle, as well as the ability to recycle or reuse the vehicle's components at the end of its life. The selection of materials 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 lifecycle, 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 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). As described in the section on Design for Lifecycle Sustainability, we use tools such as Design for Sustainability, lifecycle assessment and lifecycle costing to help us make beneficial materials choices.

For many years, Ford has had a Voluntary Recycled Content Usage Policy in North America, which sets goals 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 are also continuing to migrate successful applications of recycled and renewable content across 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 evaluated versus comparable virgin grades, to guarantee appropriate physical properties and the same level of component performance that would be obtained with virgin materials. By combining sustainable materials goals for updated or redesigned vehicles with sustainable materials identification and testing processes, we are standardizing and broadening the use of sustainable materials in our vehicles.

As we introduce sustainable materials, we are conscious that recycled materials are not always the preferable solution. For example, we take into consideration whether recycled materials may increase weight or have significant energy demand in collection or recycling. We also consider the availability of a local recycled-material feedstock versus the need for a global commonality of materials. Our global materials strategy has dramatically reduced the number of materials we specify and use, to maintain consistent quality and enable cost reductions. In some cases, the introduction of recycled and renewable materials will run counter to that commonization progress, since the feedstocks for these materials can vary by region. For example, it is often more efficient to use local waste materials that divert waste from local landfills, than to ship waste-material inputs across the globe. We are working to ensure that we use local materials as a feedstock for our recycled content materials.

## Developing and Implementing Our Sustainable Materials Strategy

## What is in a Vehicle?

Discover the kinds of materials that are in our vehicles.

## Choosing More Sustainable Materials

Explore the sustainable materials we use in our vehicles.

## Related links

This Report

- Design for Lifecycle Sustainability
- Materials Management

As our approach to sustainable materials continues to evolve, we are developing and implementing an integrated sustainable materials strategy. Progress on this effort includes the following:

- Building on our process for Restricted Substance Management: For many years, Ford has had a Restricted Substance Management Standard (RSMS), which was developed to reduce and eliminate the use of substances of concern in our vehicles and plants. The first of its kind in the industry, this standard was originally developed to address both regulated substances and materials Ford voluntarily chose to eliminate from our vehicles and plants. The RSMS system is embedded in Ford's Global Product Development System, our company-wide vehicle design and production system. We are using the same RSMS process to manage recycled and renewable materials targets and requirements in our product development system.
- 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. And, recycled materials will be consistent with EU 2003 End of Vehicle Life Regulations.
    - 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 lifecycle 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 growing).
- Integrating recycled and renewable materials into the official strategies that govern materials and commodities purchasing: We are developing global materials specifications, which will facilitate the incorporation of sustainable materials where they meet performance requirements. Such specifications will also ensure that the benefits of more sustainable materials will have a global impact. So, for example, recycled material specifications will be included in the same documents that specify virgin materials. This will simplify the monitoring of recycled content use in our vehicles and will ensure that component engineers and Tier 1 suppliers are confident in the performance of the recycled material, by means of a direct comparison with an equivalent virgin material.

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.

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 have a material specification for recycled content in a range of plastics and textiles and are working on specifications for renewable materials. These specifications make it easier for product engineers to choose sustainable material options.

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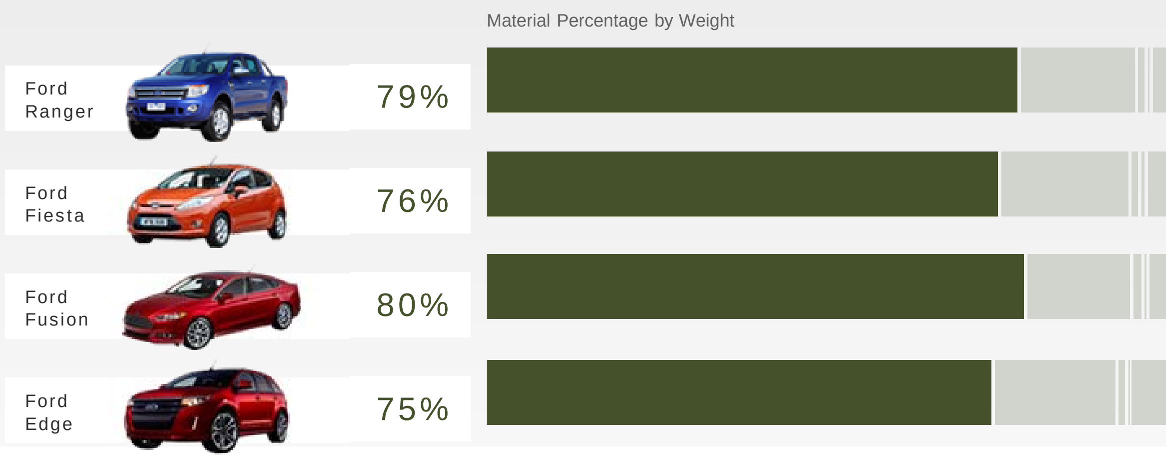
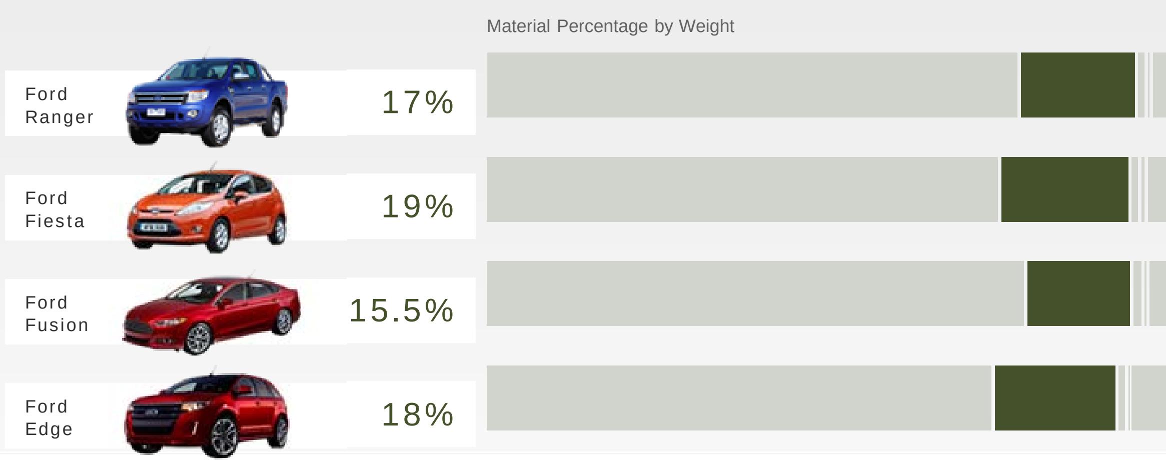
# What is in a Vehicle?

To understand our approach to sustainable materials, it is useful to understand the kinds and amounts of materials that are in our vehicles. The following graphics show the amounts of materials in several samples of our vehicles – specifically, the percentage of total weight of major material categories for each. Then, for each material category, we provide some facts about our sustainable material strategy.

## Metals



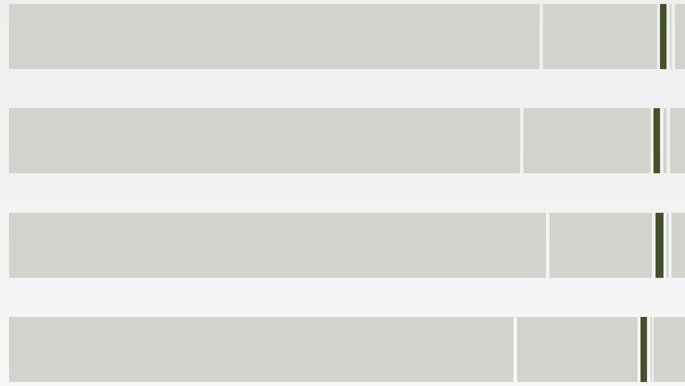

## Plastics, Textiles, and Natural Materials



## Non-Dimensional Materials

Material Percentage by Weight

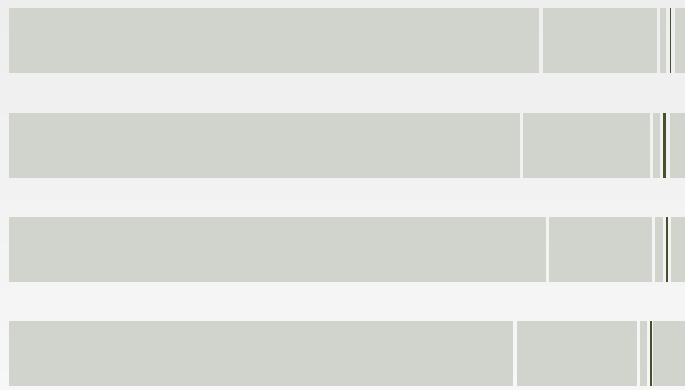
| | | |
|---|---|---|
| Ford Ranger |  | 1% |
| Ford Fiesta |  | 1% |
| Ford Fusion |  | 1.3% |
| Ford Edge |  | 1% |



## Electronics

Material Percentage by Weight

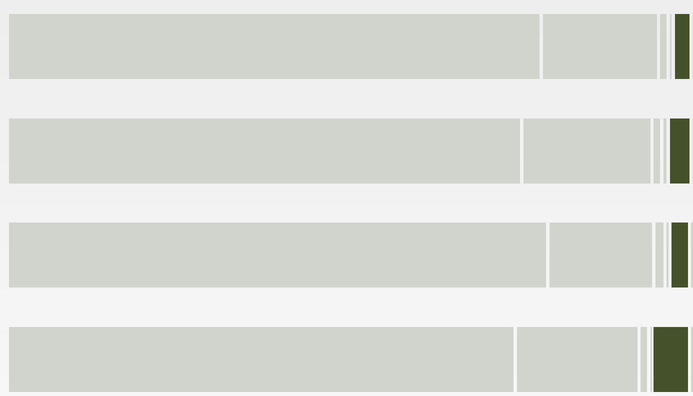
| | | |
|---|---|---|
| Ford Ranger |  | 0.2% |
| Ford Fiesta |  | 0.5% |
| Ford Fusion |  | 0.2% |
| Ford Edge |  | 0.2% |



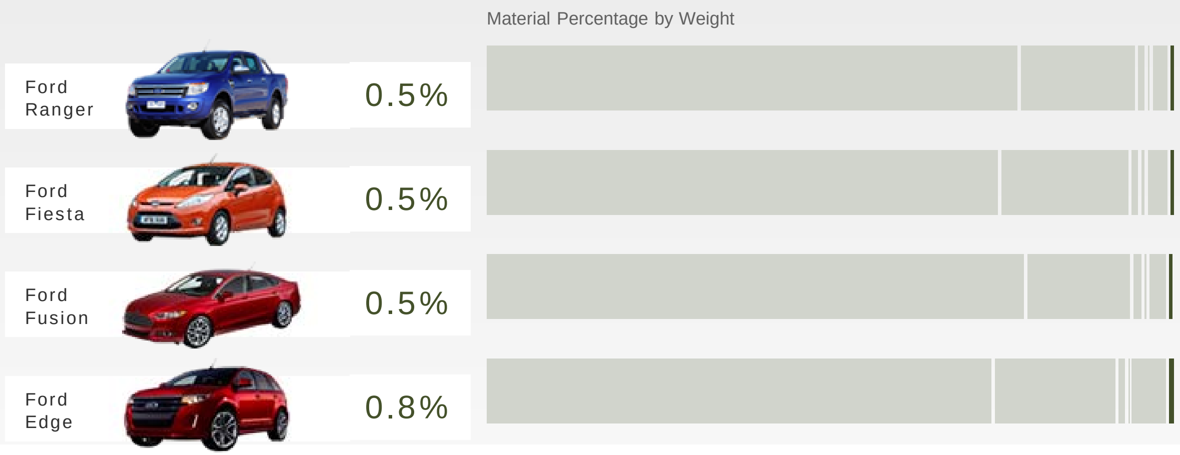
## Ceramics, Glass and Other Compounds

Material Percentage by Weight

| | | |
|---|---|---|
| Ford Ranger |  | 2.3% |
| Ford Fiesta |  | 3% |
| Ford Fusion |  | 2.5% |
| Ford Edge |  | 5% |



## Fuels and Consumable Liquids




## 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 have to balance the light weight of these materials with their relatively higher costs and energy intensity to manufacture. (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.

## Plastics, Textiles and Natural Materials

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 lifecycle 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.)

## 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-dimensionals 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 processing to reduce or recapture VOC emissions. (For more information, see Non -$CO_2$ Facilities-Related Emissions.)

## Electronics, Ceramics, Glass and Other Compounds

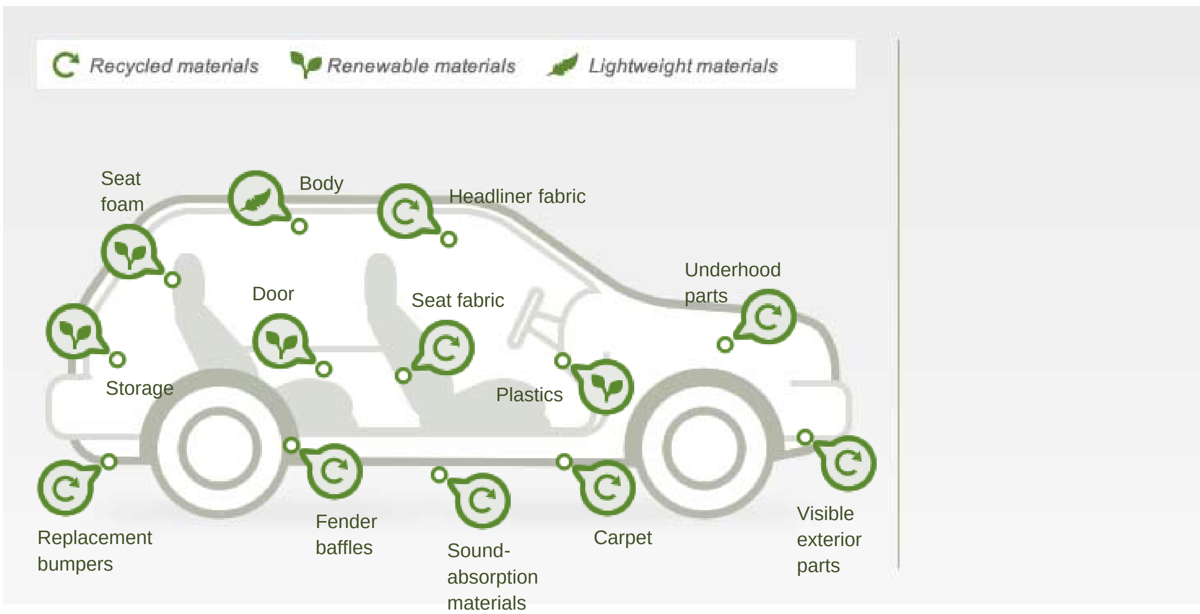
Ford has been working with our suppliers, dealers, dismantlers and industry associations (such as the USCAR Vehicle Recycling Partnership) to develop, share and implement best practices to deal with these categories of materials, which are a small percentage of any given vehicle by weight but are hard 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 rating of 95 percent.

## 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.

# Choosing More Sustainable Materials






Click on the vehicle parts to the left 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 fabric

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

## Seat foam

Starting in 2011, all vehicles manufactured in North America use seat foam made with soy oil, which reduces carbon dioxide ($CO_2$) emissions and decreases dependency 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 – including the Lincoln MKT and Ford Kuga – use aluminum and magnesium parts, which are lighter in weight than traditional steel.

### Headliner fabric

In North America, the 2012 Ford Fiesta, 2013 Econoline and 2013 Super Duty use 50–75 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 under-body systems.

### Visible exterior parts

The 2011 Super Duty uses recycled-content plastics on a range of parts, including the bumper valences, license plate brackets and fog lamp bezels.

### Sound-absorption materials

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

### Fender baffles

This noise-dampening part on the 2011 Ford Explorer is made of recycled steel from F-150 door panels, thereby reducing manufacturing-related $CO_2$ emissions.

### Storage

This noise-dampening part on the 2011 Ford Explorer is made of recycled steel from F-150 door panels, thereby reducing manufacturing-related $CO_2$ emissions.

### Door

This noise-dampening part on the 2011 Ford Explorer is made of recycled steel from F-150 door panels, thereby reducing manufacturing-related $CO_2$ emissions.

### Plastics

This noise-dampening part on the 2011 Ford Explorer is made of recycled steel from F-150 door panels, thereby reducing manufacturing-related $CO_2$ emissions.

We are working to improve the sustainability of our vehicles by using materials that are more sustainable from a total lifecycle 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

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 detergent 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 have more than 50 percent recycled materials. For example, many underbody and underhood plastic parts are made from 75 percent recycled batteries and 8 percent recycled 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.


## Related links

Vehicle Websites

- Ford Escape
- Ford Fusion
- Focus Electric
- Ford Explorer
- Ford Fiesta
- Ford Econoline
- Ford Taurus
- Ford Mustang
- Ford F-150
- Ford Super-Duty
- Ford Flex

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 improves noise vibration and harshness performance while potentially reducing 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. So far, we have recycled nearly 4.1 million pounds of carpet into cylinder head covers, the equivalent of a carpet the size of more than 150 football fields. Use of this recycled material has prevented the use of more than 430,000 gallons of oil.

In Europe, we strive to use recycled polymers in all of our vehicles, when such materials provide a more sustainable solution. In addition to recycled content in our new vehicle parts, we are also 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. Currently, dealers store them in a container that is collected by Ford for free.

In the U.S., 2013 marks 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.

Across our global operations, we are also using recycled materials for interior parts. This can be much more challenging than using recycled materials for underbody, subsurface and exterior black parts, because it is a challenge to achieve the necessary appearance and performance using recycled materials. 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 are 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 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 was introduced on the 2012 Ford Focus and is used on the 2013 Ford Fusion. Each Focus uses seat fabric made from approximately 22 plastic, 16-ounce water bottles, while the Fusion S and SE models use approximately 39 plastic bottles per vehicle. Ford partnered with the yarn manufacturer Unifi to collect bottles at the North American International Auto Show in Detroit, the Consumer Electronics Show in Las Vegas and other events throughout 2012 for use in the Focus Electric seat fabric.

The following table highlights some of the recycled-content interior materials in our recent vehicles:

| Vehicle | Material | Partner | Benefits |
|---|---|---|---|
| 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 (XLS model): 27 percent post-industrial recycled yarns | JCI/Thierry | • Reduces waste, water and $CO_2$ emissions |
| 2013 Ford Fusion S and SE Series | Seat fabric bolster: 100 percent recycled content from post-consumer and post-industrial recycled yarns<br><br>Seat fabric insert: 37 percent recycled content from post- | Sage Automotive Interiors, Unifi | • Reduces consumer and industrial waste<br>• Reduces depletion of natural resources<br>• Reduces energy consumption<br>• Uses closed-loop system for recycling manufacturing waste |

| | | | |
|---|---|---|---|
| | consumer and post-industrial recycled yarns | | |
| 2013 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<br>• Reduces depletion of natural resources<br>• Reduces energy consumption<br>• 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<br>• Reduces consumer waste to landfill<br>• Reduces depletion of natural resources |
| 2011–12 Ford Fiesta (North America) | Seat fabric: 25 percent post-consumer recycled yarns | Aunde | • Reduces consumer waste<br>• Reduces depletion of natural resources |
| | Non-woven headliner: 75 percent post-consumer recycled yarns | Freudenberg | • Reduces consumer waste<br>• 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: 25–30 percent post-industrial recycled yarns<br><br>Seat fabric bolster: 30 percent post-industrial recycled yarns | Aunde, Guilford, IAC | • Reduces waste, water and energy consumption and depletion of natural resources |
| | Carpet backing (base series): carpet insulation 40 percent post-industrial recycled yarns<br><br>Carpet backing (limited series): carpet insulation 25–28 percent post-industrial recycled yarns | IAC | • Reduces energy consumption by at least 20 percent<br>• Reduces waste by at least 17 percent<br>• Reduces $CO_2$ emissions by at least 14 percent<br>• Reduces water use by at least 9 percent |
| 2011–13 Ford Econoline | Headliner fabric: 50–75 percent post-consumer recycled content | Freudenberg | • Reduces consumer waste<br>• Reduces depletion of natural resources |
| 2011–13 Ford Super Duty | Headliner fabric: 50–75 percent post-consumer recycled content | Freudenberg | • Reduces consumer waste<br>• Reduces depletion of natural resources |
| | Seat fabric insert: 25 percent post-industrial recycled yarns<br><br>Seat fabric bolster: 30 percent post-industrial recycled yarns | Sage Automotive Interiors, Guilford, Aunde | • Reduces waste<br>• Reduces depletion of natural resources |
| 2010–13 Ford Taurus SHO | Seat fabric insert: 100 percent post-consumer recycled yarns | Miko Fabrics | • Reduces waste<br>• Reduces energy required for yarn manufacturing by 64 percent and manufacturing-related $CO_2$ emissions by 60 percent<br>• 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<br><br>Seat bolster fabric: 30 percent post-industrial recycled yarns | Aunde | • Reduces waste<br>• Reduces depletion of natural resources |
| 2010–2014 Mustang Base Series | Seat fabric insert: 18 percent post-industrial recycled yarns<br><br>Seat bolster fabric: 30 percent post-industrial recycled yarns | Sage Automotive Interiors, Guilford | • Reduces waste<br>• Reduces depletion of natural resources |
| 2010–13 Ford F-150 XL, XLT & FX4 | Seat fabrics: 25 percent post-industrial recycled yarns | Sage Automotive | • Reduces waste<br>• Reduces depletion of natural resources |

| | | | |
|---|---|---|---|
| | FX4 model seat fabrics are 18 percent post-industrial yarns | Interiors, Guilford, Aunde | |
| 2010 European Ford Focus RS (fabric option) | Seat fabric insert: 100 percent post-consumer recycled content | Miko Fabrics | • Reduces waste<br>• Reduces energy required for yarn manufacturing by 64 percent and manufacturing-related $CO_2$ emissions by 60 percent<br>• Uses only neutral, nontoxic dyes and no harmful solvents in the fabric manufacturing process |
| 2013 Ford Flex SE and SEL Series | Seat fabric insert: 35 percent post-industrial recycled yarns | Sage Automotive Interiors, Aunde | • Reduces industrial waste<br>• Reduces depletion of natural resources<br>• Reduces energy consumption |
| 2013 Ford Fusion S and SE Series | Seat fabric bolster: 100 percent post-consumer and post-industrial recycled yarns<br><br>Seat fabric insert: 37 percent post-consumer and post-industrial recycled yarns | Sage Automotive Interiors, Unifi | • Reduces consumer and industrial waste<br>• Reduces depletion of natural resources<br>• Reduces energy consumption<br>• 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<br>• Reduces depletion of natural resources<br>• Reduces energy consumption<br>• Uses closed-loop system for recycling manufacturing waste |

We have also expanded the use of recycled materials in several visible exterior applications. For example, the 2011 Ford Super Duty used material derived from recycled battery casings on several aesthetic parts, such as license plate brackets, the 4x2's bumper valence panel and the fog lamp bezels. These parts are "molded in color" and color-matched to provide visual harmony. The Super Duty also used post-industrial and post-consumer recycled plastic for its fascia lower valence.

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 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.

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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. The first Ford vehicles used soybean oil in plastic body panels and paint, as well as wheat-straw-reinforced steering wheels. We are continuing this legacy today.

We are actively researching and developing renewable materials and applications that will reduce our dependence on petroleum and reduce our carbon footprint, while providing superior performance. Research scientists at Ford's Research and Innovation Center in the U.S., Ford's Research Center in Aachen, Germany, and Ford of Brazil are focused on developing automotive foams, plastics and composites that are derived from renewable resources. Ford is now a recognized leader in bringing high-performance, durable, plant-based materials to millions of vehicles every year.

Since 2002, our researchers have pioneered the research and development of soy-based polyurethane foams for automotive applications. The use of soy foam reduces $CO_2$ emissions, decreases dependency on petroleum oil and increases the utilization of renewable agricultural commodities. Soy foam also offers the potential for cost savings as well as insulation from petroleum product price swings.

In 2007, Ford was the world's first automaker to implement this innovative technology (on the seat cushions and seat backs of the 2008 Ford Mustang), and we have since migrated its use across all of our vehicle lines produced in North America. As of 2011, all Ford Motor Company 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 sustainable bio-based foam.

Ford currently has soy foam seats in more than 8 million vehicles on the road, which reduces petroleum oil usage by more than 5 million pounds annually. Lifecycle 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. 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 bio-renewable soybean oils and post-consumer, recycled tires. This material is currently used in 14 of our vehicle lines, including the Ford Escape, F-150, Focus, Mustang and Taurus. The use of these greener gaskets and seals has diverted more than 2 million pounds of used tires from landfills and has used approximately 1.4 million pounds of soybean oil.

Ford has also pioneered the use of soy oil in rubber. By using renewable soy oil as a 25 percent replacement for petroleum oil, Ford researchers more than doubled the rubber's "stretchability" and at the same time reduced its environmental impact. 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.

We have continued to expand our use of sustainable elastomer applications. Scientists within Ford Research have developed a patented technology using soy-based rubber in plastic applications. And we are currently researching the potential of soybean oil in exterior rubber parts, with funding from the United Soybean Board. In 2002, Ford joined a university- and industry-based collaborative effort called the Program of Excellence in Natural Rubber Alternatives, to investigate and develop new technologies related to alternative sources for rubber and latex.

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 and does not compete with food sources. 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.

We also use renewable materials to reinforce plastic and for other applications in vehicle materials. For example, the average Ford vehicle sold in Europe uses between 10 and 20 kilograms of renewable materials, depending on the vehicle size class. Almost 300 parts used across Ford's European vehicles are derived from sources such as cotton, wood, flax, hemp, jute and natural rubber. Also in Europe we use Lignotech, a compression-molded polypropylene and wood material in the door panels of the Ford Focus and Fiesta. And we use kenaf to reinforce compression-molded plastic in door parts. We have used this material in Europe for many years in door-panel inserts. For example, the Ford Mondeo uses a mixture of 50 percent kenaf plant fiber and 50 percent polypropylene in the compression-molded interior door panel.

We also use kenaf to reinforce plastic in North America – in particular in the door interior bolsters on the Ford Escape. Kenaf, which is a tropical plant that looks similar to bamboo and is related to cotton, replaces some of the oil-based resin in the plastic. The use of kenaf in this part offsets 300,000 pounds of oil-based resin per year in North America. In addition, the material reduces the weight of the door bolsters by 25 percent, which translates into better fuel efficiency. In North America we also use a coconut-fiber trunk liner in the 2012 Focus Electric.

In 2009, Ford introduced the world's first application of wheat-straw-reinforced plastic, which we developed in conjunction with the Canadian BioCar initiative, in the third-row storage bins of the Ford Flex. For this application, wheat straw is used to replace the glass fibers or minerals commonly used to reinforce plastic parts. The use of wheat straw is a highly efficient use of natural fiber, because it is a byproduct of growing wheat that is typically discarded or burned. 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. The material weighs up to 15 percent less than plastic reinforced with glass or talc. Additional applications of wheat-straw-reinforced plastics under consideration by the Ford team include console bins and trays, climate-control air ducts, door trim panel components and armrest liners.

The injection-molding technique that Ford first pioneered to include wheat straw in interior parts is now being adapted by Ford researchers for use with other natural fibers such as hemp and sisal. These new processes will allow us to make increasingly complex components including natural fibers and increase the number of natural-fiber-reinforced applications. The environmental benefits of natural-fiber-reinforced plastics can include reducing component weight (especially when replacing glass fibers) and allowing lower production temperatures (approximately 40 degrees lower than conventional plastic). Using the fibers can also have social benefits. Sisal, for example, which thrives on marginal land in hot and arid conditions, is of major economic importance to some developing countries and communities.

We are using engineered wood technology, which comes from a certified, sustainably managed forest and is a renewable resource, on several interior applications in North American vehicles. This wood, which is harvested under strict guidelines, is assembled into a composite and then stained to give it a warm, rich appearance. In addition, the use of engineered wood eliminates many of the extra processing steps necessary in producing solid wood automotive trim parts, and the processing required is more environmentally friendly. For example, water-based stain can be used instead of solvent-based, and a solvent wash to remove oils is not needed. Additional bleaching and sealing operations are eliminated, which greatly reduces the production of VOCs. Engineered wood technology uses input materials more efficiently, so less waste material is sent to landfills.

Engineered ebony wood was implemented on the 2008 Lincoln Truck, the 2008 and 2009 Navigator, the 2008 MKX and the 2009 MKS. The 2012 and 2013 Lincoln MKX, MKZ and Navigator use California plantation-grown swirl walnut veneer. This locally grown veneer is manufactured with a warm lacquer process that reduces the number of topcoats required and thereby lowers related VOC emissions from the production process.

For the past few years, Ford has been working with forest products leader Weyerhaeuser to develop a plastic composite material that uses cellulose fibers from trees in place of fiberglass or mineral reinforcements. The cellulose fibers in this new composite come from sustainably grown and harvested trees and related byproducts, such as wood chips, which reduces the material's environmental footprint. In addition, replacing fiberglass, minerals and/or petroleum with a natural, plant-based material can sequester $CO_2$ and ultimately lead to a smaller carbon footprint. So far, we have found that Weyerhaeuser's cellulose-based plastic composite materials meet our stringent requirements for stiffness, durability and temperature resistance. Furthermore, the components weigh about 10 percent less and can be produced 20 percent to 40 percent faster and with less energy when made with cellulose-based materials compared with fiberglass-based materials. These weight and process savings can enable equivalent or reduced component costs. Several prototype parts are currently being tested.

In 2012, Ford joined with The Coca-Cola Company, H.J. Heinz Company, NIKE, Inc., and Procter & Gamble to form the Plant PET Technology Collaborative (PTC), a strategic working group focused on accelerating the development and use of 100 percent plant-based PET materials. The partnership will build on the success of The Coca-Cola Company's PlantBottle™ packaging technology, which is partially made from plants and has demonstrated a lower environmental impact when compared to traditional PET plastic bottles. 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 lifecycle analyses and universal terminology.

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 materials. Rubber-modified plastics are common, especially in interior applications where low temperature impact is important.

Finally, Ford researchers are continuing to work with polylactic acid (PLA) – a biodegradable plastic derived completely from the sugars in corn, sugar beets, sweet potatoes, sugar cane, Indian grass and other plants. When plastic parts made from PLA reach the end of their useful life, they can biodegrade in 90 to 120 days. In contrast, traditional petroleum-based plastics are projected to remain in landfills for hundreds of years. Several technical issues must be overcome before these compostable plastics and fabrics meet our stringent wear, performance and durability requirements, but they hold great promise for future vehicles.

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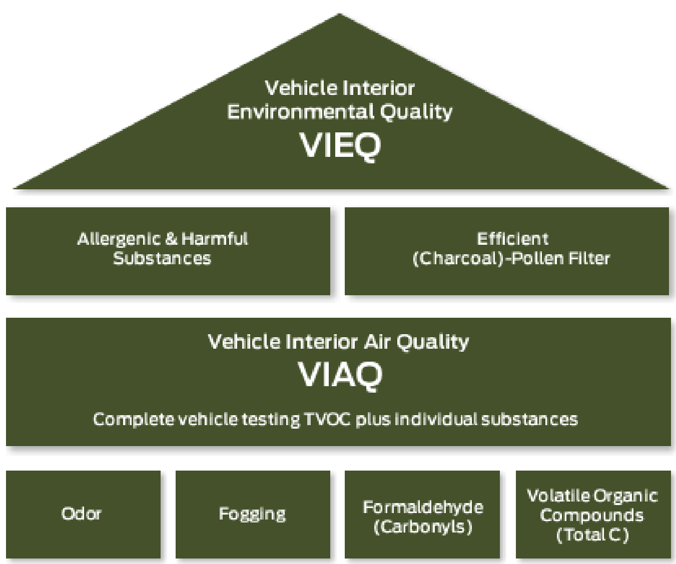
# Improving Vehicle Interior Environmental Quality and Choosing Allergy-Tested Materials

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.

Specifically, this team has been working since 2007 to develop 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 and Africa operations in the future.

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 could be uploaded into the driver's approved health data cloud and processed with other health data to create graphical reports the driver could 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

This Report
- Materials Management

External Websites
- REACH

## Eliminating Mercury

Ford has decreased 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 the U.S. 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 2012, more than 5.3 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 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.

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## Eliminating Chromium and Lead

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 EPA 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, lifecycle 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.

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## 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 (Deca-BDE), another substance of concern that the EPA has 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.

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 will adopt REACH regulations in 2013 and will begin implementation in 2015. In the U.S., the federal Senate and House both proposed bills in 2010 to overhaul the Toxic Substances Control Act. The state of California is finalizing a Safer Consumer Products law, which will take 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.

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# 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 2012, 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 85–95 percent recoverability requirement.

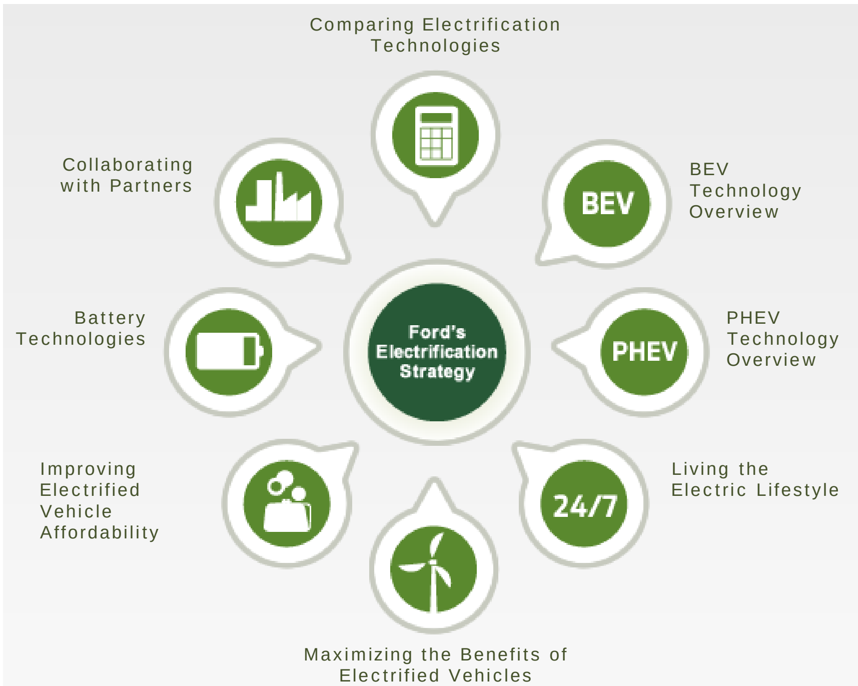
Ford has participated in research into alternative treatments for end-of-life vehicles. Most of the plastic, foam and other nonmetal vehicle materials end up being shredded. Most of this “auto shredder residue” (ASR) ends up going to landfill. We have been working to assess the environmental impacts of burning ASR for energy. Together with other European automotive manufacturers, we sponsored a fully ISO 14040-compliant lifecycle 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 – which include hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs) and full battery electric vehicles (BEVs) – has 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 electrified vehicles grew to just 2 percent of the total U.S. passenger vehicle market. But from 2011 to early 2013, the market for electrified vehicles 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. At the same time, utilities are working to understand how to provide power to plug-in vehicles in a way that is effective in meeting consumer needs, efficient for electricity providers and 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 electrified vehicles? As gas prices remain high, consumers are increasingly interested in alternative and less-expensive fueling options, such as electricity. In addition, the cost of electrified vehicles continues to come down, due in part to rapidly advancing electrified vehicle technology. Other benefits 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 electrified vehicles (especially HEVs) are beginning to become more competitive, they remain relatively high. In addition, consumers continue to have concerns about the driving range of PHEVs. And for

## 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.

## Related links

This Report

Sustainable Technologies and Alternative Fuels Plan

electrified vehicles to achieve their full potential to cut lifecycle automotive GHG emissions, low-carbon electric 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 lithium and rare earth metals. Furthermore, customer demand for electric vehicles must continue to grow for these vehicles to have a significant effect on overall transportation-sector emissions without the use of subsidies and incentives.

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.

# Ford's Electrification Strategy

Ford's electrification strategy foresees a future that includes different types of electrified vehicles, 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.

Ford's Michigan Assembly Plant is the first in the world to build vehicles with five different fuel-efficient powertrain technologies on the same production line.

Related links

Vehicle Websites

- Focus Electric
- C-MAX Energi
- Fusion Energi
- Fusion Hybrid
- C-MAX Hybrid
- Lincoln MKZ Hybrid

Ford Websites

- Electrified Vehicles
- Plug into Ford

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

Electrified vehicles are an important part of Ford's overall sustainability strategy and our commitment to reducing 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 creating 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

As of June 2013, we offered three HEVs: the Ford Fusion Hybrid, the Lincoln MKZ Hybrid and the new C-MAX Hybrid (based on the successful C-MAX in Europe), all of which deliver leading fuel economy. 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; the Fusion and C-MAX Hybrids available in the U.S. both have a U.S. Environmental Protection Agency (EPA) estimated rating of 47 mpg in the city, on the highway, and combined.[1] For more information about our hybrid vehicles and technology, please see the Hybrid Electric Vehicles section.

In the spring of 2012, we launched the Focus Electric, a BEV version of the new Ford Focus, to retail customers in North America. The Focus Electric has an EPA-estimated fuel- efficiency rating of 110 miles per gallon equivalent (MPGe) city and 99 MPGe highway.[2] By using innovative technologies, the Focus Electric can be fully charged in 4 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 29 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 Focus Electric

Ford C-MAX Energi and Ford Fusion Energi

In North America, we also now 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. The C-MAX Energi and Fusion Energi both have an EPA-estimated rating of 108 city/92 hwy/100 combined MPGe.[3] The C-MAX Energi has an EPA-estimated 620 mile range.[4] For more information about our PHEVs and technology, please see the Plug -In Hybrid Electric Vehicles section.

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

We plan to expand our electrified vehicle lineup to Europe in late 2013, beginning with the Focus Electric. We will also launch hybrid vehicles in Europe in coming years.

Sales of our electrified vehicles are increasing, and Ford recently became the second-leading seller of electrified vehicles. As of April 2013, we held an 18 percent market share in the U.S. electrified vehicle market, up from approximately 3 percent in 2012. HEVs make up a significant portion of our total electrified-vehicle sales. In the five months from December 2012 to April 2013, we sold more HEVs than in any full year since we began selling hybrids in 2004. The C-MAX and Fusion Hybrids are proving particularly effective at bringing new people to Ford-brand vehicles. As of April 2013, 64 percent of C-MAX Hybrid customers and 68 percent of Fusion Hybrid customers were new to the brand.

To meet the ever-growing demand for electrified vehicles, we are tripling our electrified vehicle production capacity by the end of 2013. This increase is based on our expectation that gas prices will rise over time and continue to drive increased demand for more fuel-efficient vehicles, including HEVs, PHEVs and BEVs. We expect HEVs to make up about 70 percent of our share of electrified vehicle sales. In 2012, HEVs made up approximately 1.6 percent of Ford’s total U.S. sales.

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## Using Global Platforms

We are basing our electrified vehicle 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

Electrified vehicles have many advantages for consumers. But they also require drivers to make changes to their driving routines 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 electric vehicles (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., for example, 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 to know how far they can go until the next charge based on their own driving style. For example, our innovative MyFord Mobile® app, developed using MapQuest® and Xatori technology, allows owners to control charging and other in-vehicle operations remotely. The app can “wake up” to pre-heat or pre-cool 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 Xatori’s 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 electric vehicles that are as engaging, easy to use and empowering as other forms of consumer electronics like smartphones.

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## Bringing EVs to Market Thoughtfully

Ford is taking a proactive approach to making PHEVs and BEVs successful in the marketplace. We are working with utilities, municipalities, dealers and customers to make the transition to these EVs as smooth as possible.

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 onsite 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. As of March 2013, we have certified more than 600 dealers in 48 states to sell our electrified vehicles and have more than 200 additional dealers signed up to undergo the certification process during the remainder of 2013. This is more than triple our original estimate for certified EV dealers – another sign of growing interest in these vehicles. For more information, please see the Dealers section.

We have also developed websites, videos and brochures to help consumers understand our electrified vehicle offerings and incorporate BEVs and PHEVs into their lifestyle. For example, our electrified-vehicle 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.

In addition, we targeted our initial BEV offerings in markets that were able to take advantage of the full range of BEVs’ benefits right away. We initially introduced the Focus Electric in the largest electrified vehicle markets – New York, New Jersey and California – which have some of the most established, fastest-growing charging station infrastructures and government support. We followed this initial vehicle launch with a rollout in the fall of 2012 to 15 additional U.S. metropolitan areas, which were chosen based on several criteria, including commuting patterns, existing hybrid purchase trends, utility company collaboration and local government commitment to electrification.

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” tour in 14 cities around the country 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. In 2012, we also held more than 25 consumer education events in key BEV and PHEV markets around the country; some were standalone 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. We are continuing our consumer-education efforts in 2013 with at least 27 additional events and a goal of providing at least 10,000 test-drive experiences.

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## Collaborating with Partners

The development and diffusion of electrified vehicle technologies is a global challenge. Major advances have already been made on the electrical technology at the core of next-generation electrified vehicles, and there's more to come. We are working with a coalition of other automotive manufacturers and other stakeholders to develop technologies, standards and cost efficiencies to commercialize electrified vehicles. It will take a collaborative approach of automakers, battery producers, suppliers, fuel producers, utilities, municipalities, educators and researchers, as well as policy makers and opinion shapers, to help us make the transition and realize the full benefits of electrification.

Traditional automotive suppliers, transforming themselves for electrification, are being joined by new suppliers adapting electronics to the automotive environment. Significant possibilities exist for innovation in battery technology, power electronics and the development of motors, generators, high-voltage systems and other components, as well as the information technology necessary to maximize the potential of electric vehicles.

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.

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. For more information on this partnership, see Collaborating with Partners

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1. Actual mileage will vary.
2. EPA-estimated rating of 110 city/99 hwy/105 combined MPGe. Actual mileage will vary. MPGe is the EPA equivalent measure of gasoline fuel efficiency for electric mode operation.
3. Actual mileage will vary. MPGe is the EPA equivalent measure of gasoline fuel efficiency for electric-mode operation.
4. EPA-estimated rating of 44 city/41 highway/43 combined. 14 gallon tank; 21 miles electric. Range calculations based on www.fueleconomy.gov. Actual mileage will vary.

# Comparing Electrification Technologies

Electrified vehicle 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 have different benefits and different ideal 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. We are also working with SHFT.com on a series of short films aimed at clarifying the different technologies for consumers. Ford also has an electrified-vehicle website 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 chart below compares a range of vehicle types, from conventional gasoline to pure battery electric. In the near term and mid-term, the largest volume of electrified vehicles will likely be hybrid electric vehicles, which use both a gasoline engine and a battery electric motor but do not plug into the electric grid. In the U.S., HEVs made up approximately 2.8 percent of the market for new vehicles in 2012. In the longer term, electrified vehicles that get some or all of their energy directly from the electric grid – including PHEVs and BEVs – are likely to play an increasingly significant role. 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 Start/Stop 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 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. 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 | Flexible for a wide range of uses. Dramatically improved fuel economy. Suitable for customers who | Ideal for customers with access to a charging station at home or work who have shorter, |

Related links

Ford Websites

- Electrified Vehicles
- Plug into Ford

| | | | | | |
|---|---|---|---|---|---|
| | | | economy. | have access to a 120V outlet or 240V charging station at home and/or the office. Can provide approximately 20 miles in pure electric mode, but is flexible for longer trips as well. | predictable daily trips of less than 80 miles (between charges). |
| Technology Benefits/Costs Based on a Typical Compact or “C-class” Sedan [3] | | | | | |
| Fuel economy [4] | ˜31mpg | ˜32 mpg | ˜47 mpg [5] combined city and highway | 100 MPGe [6] (combined city and highway) in electric mode. Similar to HEV when running on gasoline in hybrid mode. | 105 MPGe [7] |
| Range on tank/charge [8] | ˜380 miles/tank | ˜470 miles/tank | ˜570 miles/tank | ˜620 miles on combined gas and electric power. More than 1,200 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. | 4 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 | ˜35 g/km | ˜40 g/km | n/a |
| Tank to wheels [11] | ˜165 g/km | ˜160 g/km | ˜110 g/km | ˜110 g/km | n/a |
| Total $CO_2$ [12] | ˜215g/km | ˜210 g/km | ˜145 g/km | ˜145 g/km [13] | ˜130 g/km |
| Annual fuel cost | ˜$1,200–1,900 [14] | ˜$1,200–1,900 [15] | ˜$800–1,300 [16] | ˜$600–900 ($400–700 for gasoline + $200 for electricity) [17] | ˜$400 [18] |

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 40?50 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 petroleum gasoline.
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. 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.
13. 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.
14. Based on 12,000 miles/year, 31 mpg and $3–5/gallon.
15. Based on 12,000 miles/year, 32 mpg and $3–5/gallon.
16. Based on 12,000 miles/year, 47 mpg and $3–5/gallon.
17. Based on 12,000 miles/year, 50 percent in electric mode at 3.5 miles/kWh (midpoint of range of 3–4 miles/kWh in electric mode) and 12 cents/kWh, and 50 percent in gasoline-engine mode at 43 mpg and $3–5/gallon.
18. Based on 12,000 miles/year, 3.5 miles/kWh (midpoint of range of 3–4 miles/kWh for a typical BEV) and 12 cents/kWh.

Climate Change and the Environment

- Design for Lifecycle Sustainability
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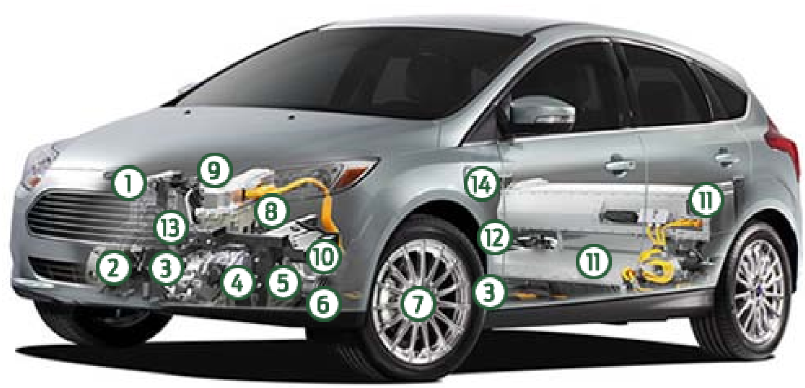
- Greening Our Operations
- Data
- Voice: Mark Lee

# BEV Technology Overview

## Ford All-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

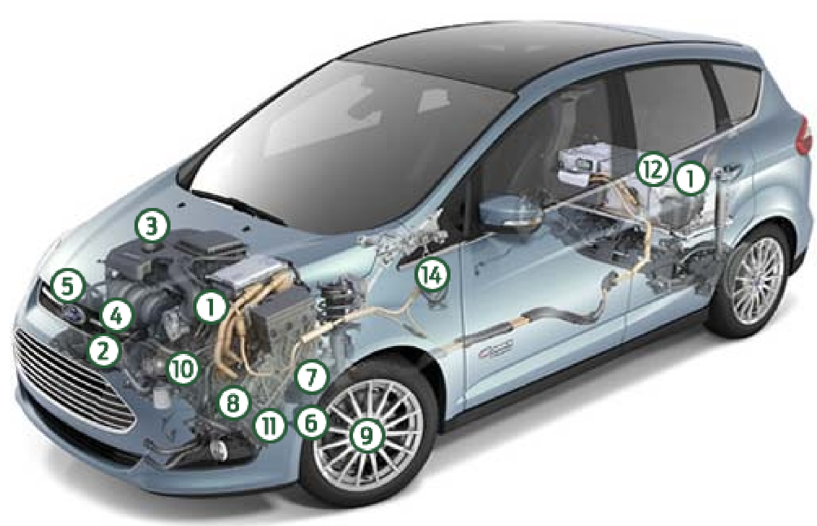
A standard SAE J1772 plug interface is used for charging. Ford's charge port "light ring" provides an external indicator of charging status.

# 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®

### 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 240 V charge station installed in the customer's garage.

### The only plug-and-play charging system

Ford is currently the only auto manufacturer to offer a "plug-and-play" charging system that is easy to install and portable, so you can take it with you if you move.

### 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.

### 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.

### Locate your vehicle

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

### 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.

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 exactly how far they can go until the next charge based on their own driving style. We have also enabled drivers to link 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 Smart Gauge® with EcoGuide

We designed our battery electric and plug-in hybrid vehicles to provide more range at full charge than most Americans will use each day. But we know that, 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 several regions, including the U.S., our electric vehicles include an enhanced version of SYNC® with MyFord Touch® – Ford’s driver interface technology – that includes next-generation Smart Gauge® with EcoGuide. Smart Gauge with EcoGuide gives drivers real-time feedback on the efficiency of their driving habits and tips on driving more efficiently. The system also helps drivers plan the most environmentally responsible route and manage the battery-recharge 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 can get an increased range out of their car than those who drive more aggressively. 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® with next-generation Smart Gauge® gives drivers real-time feedback on the efficiency of their driving habits and tips on driving more efficiently.

The system also includes a trip-planner feature to help 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.

Related links

Ford Websites

- Plug into Ford

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" that make it easy for drivers to quickly interpret information.

Finally, Smart Gauge 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 start the vehicle and 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, 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 Traffic, Directions and Information program in the Ford SYNC system. 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; it includes reviews, photos and station locations from crowd sourcing as well as location and availability information from charge-station providers 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. All 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.


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. Through PlugShare, drivers can 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 Innovation Design and Engineering Award at the 2012 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). We have gone to great lengths to make our charging systems fast, easy and economical.

The Focus Electric uses a 6.6 kW charger, which enables an at-home charge time of four hours when using a 240 V 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 charged up and 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. Ford electric vehicles are the first to work with this charge management system. 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.

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 charge initiation. 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 just purchase the charging station and install it themselves or use an electrician of their choice. Or, customers can choose a full installation option, in which installation services are provided through 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 as quickly as one day, at a time and date selected by the customer.[1] The customer can use either a website or call center (1.888.219.6747) 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. 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

Full 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 misleading, 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). (See the well-to-wheels $CO_2$ emissions values on the Comparing Electrification Technologies page.)

In some regions of the country, however, where electrical power is derived largely from cleaner and/or renewable 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.)

To help customers think through the relative lifecycle 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. The calculator allows the customer to input factors such as vehicle type (e.g., hybrid, battery electric, diesel, flex-fuel), electricity source by U.S. region or fuel (e.g., coal, nuclear, renewables, natural gas) and likely driving patterns (e.g., stop-and-go city traffic, highway driving or a mix). These key factors help determine the relative environmental benefits the customer may achieve with each type of vehicle and fuel. For a customer deciding where to place an EV in their 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.

## 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 entirely the need for petroleum.

The U.S. currently imports just under 50 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. Electric motors are approximately 3–4 times more efficient than traditional internal combustion engines. In addition, electric-drive vehicles do not consume energy while at rest or coasting, and more than 93 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.

## Maximizing Charging Efficiency

As mentioned above, 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 Collaborating with Partners 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 $2–3 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. Specifically, 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 worked closely with SunPower to ensure the unit would be available below a $10,000 price point (including incentives), which makes it the most affordable rooftop solar system of its kind and allows us to make the benefits of solar charging available to more of our customers.

"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. 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. Approximately 45 million homes in the U.S., or about one third of households, were equipped with a smart meter as of December 2012, and experts predict that 65 million households will be equipped by December 2015.

Value Charging: Value Charging, which is 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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# 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 Technology 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) – over 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 just less than $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 $3–5/gallon for the gasoline vehicle.

# Battery Technologies

Until recently, hybrid electric vehicles (HEVs) ran on nickel metal hydride batteries, which offer significant improvements over traditional lead-acid batteries. For example, nickel metal hydride batteries deliver twice the power output for the weight (energy density) compared to lead-acid batteries. Nickel metal hydride batteries have worked well in (non-plug-in) hybrid electric vehicles (HEVs), as these batteries are designed to allow for constant discharging and recharging and are not expected to store and provide large amounts of energy. However, they are reaching the end of their advancement potential.

Plug-in hybrid electric vehicles (PHEVs) and pure battery electric vehicles (BEVs) make significant additional demands on battery technology that nickel metal hydride batteries are not equipped to handle. Unlike HEVs, which maintain a narrow state of charge window, PHEV batteries are intended to be depleted to a low level when they are the primary energy source for the vehicle. And BEVs are designed to run solely on battery power. The batteries used in PHEVs and BEVs must function well in a wide range of conditions; tolerate running until nearly depleted and then being fully charged; store and provide a lot of power; last a minimum of 10 years or 150,000 miles; and, ideally, be compact and lightweight. Because nickel metal hydride batteries have significant limitations for such applications, automakers, including Ford, are now offering lithium-ion batteries for current-generation HEVs and for PHEVs and BEVs. These batteries are lighter and smaller than nickel metal hydride batteries. Even so, the technology is still evolving, as discussed below, and costs are still relatively high.

It is also important to have a plan for recycling batteries at the end of their useful lives to minimize the material going to landfill.

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## Battery Evolution

Battery technology has been evolving. The following table shows how new battery technologies, such as the nickel metal hydride batteries used in previous HEVs and the lithium-ion battery technology in the current generation of electrified vehicles, compare to the traditional 12-volt lead-acid battery.

| | Lead-Acid | Nickel Metal Hydride (Ni-MH) | Lithium-Ion (Li-ion) |
|---|---|---|---|
| First commercial use | 1859 | 1989 | 1991 |
| Current automotive use | Traditional 12-volt batteries | Developed for first-generation hybrid vehicles | Developed for current-generation hybrid electric and battery electric vehicles |
| Strengths | Long proven in automotive use | Twice the energy for the weight compared to lead-acid; proven robustness | About twice the energy content of Ni-MH and better suited to plug-in electrified vehicle applications; by taking up less space in the vehicle, provides far greater flexibility for automotive designers |
| Weaknesses | Heavy; its lower energy-to-weight ratio makes it unsuitable for electrified vehicle usage | High cost (four times the cost of lead-acid); limited potential for further development | Expensive until volume production is reached |
| Specific | 30–40 | 65–70 | 100–150 |

| | | | |
|---|---|---|---|
| energy (watt hours per kilogram) | | | |
| Recyclability | Excellent | Very good | Very good |

## 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 all-electric vehicles, because extreme temperatures can affect performance, reliability and durability.

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? Attention is also focusing on the possibility of risks such as bribery and corruption and the potential for environmental and human rights abuses. 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 of electric vehicles through at least the year 2100.[1] We are now conducting a study of rare earth element availability and demand with scientists at the Massachusetts Institute of Technology. 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 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, and we assess compliance with our Code in target markets. 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).

# Collaborating with Partners

Clearly, electric vehicles (EVs) will have an impact on electric utilities and on consumers' use of electricity in their homes. 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. To maximize recharging efficiency and minimize stress to the grid, "smart grid" technology that allows communication between recharging vehicles and the electrical grid will be required. 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.

In 2007, Ford was awarded $10 million by the U.S. Department of Energy as part of an effort to identify a sustainable path toward the successful mass production of plug-in hybrid electric vehicles. This included collaboration with the Electric Power Research Institute (EPRI) and several utility partners in the evaluation of a demonstration plug-in hybrid prototype fleet. Real-world driving and charging performance was evaluated in different geographical locations. This demonstration was completed in December 2012, having successfully logged over 800,000 miles. Many of the results from this demonstration have been made publically available through collaboration with Idaho National Laboratories (INL). The INL has analyzed the vehicle data collected from nearly 20,000 charge events and 50,000 drive events and created summary reports which are available on the INL advanced vehicle technologies website.

All plug-in hybrid electric vehicles in this demonstration fleet were equipped with vehicle-to-"smart-meter" communication capability. Working with a collaborating utility, EPRI conducted vehicle-to-grid connectivity testing and successfully demonstrated that vehicle-to-smart-meter communications are feasible. 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 also working with utilities, municipalities and states across the country to develop and facilitate the use of EV implementation best practices. 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 at least 12,000 public charge stations in cities throughout the U.S. and Canada, up from about 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: As of early 2013 approximately 42 million smart meters had been installed in the U.S., up from about 36 million in spring 2012. Currently about 30 percent of the 130 million homes in the U.S. have smart meters; utilities in 16 states have fully deployed the technology.

- 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.

In January 2013, we signed onto the U.S. Department of Energy's pledge to increase vehicle charging infrastructure available in workplaces across the country. 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. To fulfill this pledge, Ford is assessing our workforce electrified vehicle charging demands, and developing and implementing a plan to install workplace charging infrastructure for at least one major worksite location. By installing stations for use by employees and visitors to supplement, not replace, their home charging, this program will help EV owners maximize their miles driven and increase the usability of their vehicles.

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## 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.

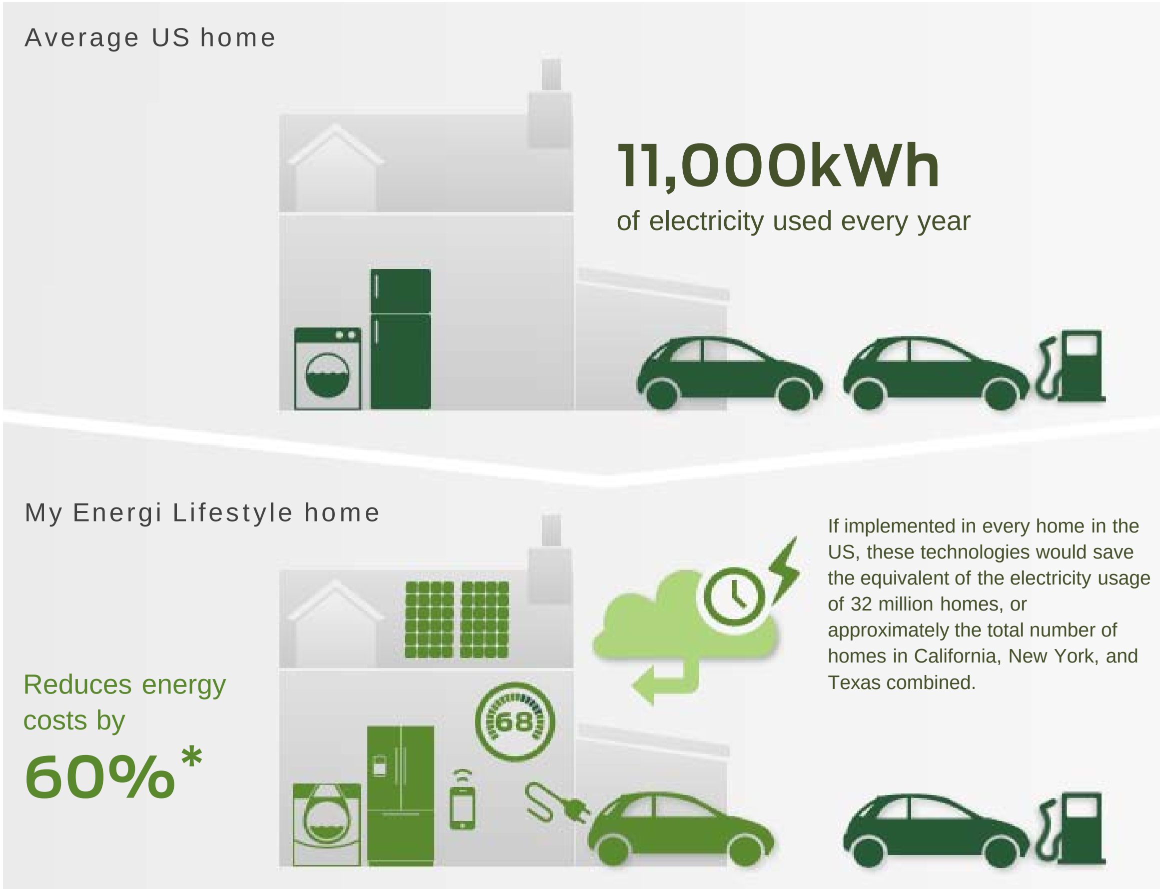
The Ford-led project, which currently includes Whirlpool, Eaton, SunPower and the Georgia Institute of Technology, shows that more efficient and coordinated use of home electricity for appliances and electric vehicles can, on an annual basis, reduce a home's electricity use by up to 55 percent, reduce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

These results are based on computer simulation of an average American home developed in partnership with the Georgia Institute of Technology. The model compares 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.

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).

## My Energi 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.




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

The next step in the project is to apply these changes to real-world homes, which we will choose through a still-to-be determined contest. The real-world homes will receive a package of appliance upgrades, renewable energy installations, other energy efficiency retrofits, and Ford Focus Electric and C-MAX Energi vehicles to parallel the changes made in our computer simulations of an average home.

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# Greening Our Operations

We have adopted a rigorous and holistic approach to reducing the overall environmental impacts of our manufacturing facilities. We have established global facility environmental targets that address the range of our environmental impacts, including energy use, emissions, water use and waste generation.

Each Ford facility 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. These targets include reducing greenhouse gas emissions from our manufacturing facilities by 30 percent on a per-vehicle basis from 2010 to 2025 and reducing average energy consumption per vehicle globally by 25 percent from 2011 to 2016. Our targets and progress are shown in the Goals, Commitments and Status chart.

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 consumption, energy use, carbon-dioxide ($CO_2$) 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.

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.

Related links

This Report

- Ford's Goals, Commitments and Status

# 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 by 2025 on a per-vehicle basis. This $CO_2$ goal, which is also based on our stabilization commitment, complements our longstanding 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.

Related links

This Report

Climate Change

## 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.
- We were the first automaker to participate in GHG reporting initiatives in China, Australia, the Philippines and Mexico. In Mexico, Ford's first report was used as the template for subsequent reporting in that program. Ford of Mexico's GHG report has also been third-party verified, and was recognized by Mexican authorities for this achievement.
- We voluntarily report GHG emissions in the U.S., Canada, Argentina, Australia, Brazil, China, Mexico, 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 five Ford facilities in the UK, Belgium and Spain.
- In the U.S., the EPA issued a final rule on September 22, 2009, establishing a national GHG reporting system. Facilities with production processes that fall into certain industrial source categories, or that contain boilers and process heaters and emit 25,000 or more metric tons per year of GHGs, are required to submit annual GHG emission reports to the EPA. Many of our facilities in the U.S. are subject to the reporting requirements and submit reports as required.

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

## Performance

In 2012, Ford established a five-year objective to improve our operational energy use per vehicle globally by 25 percent by the end of 2016 based on a 2011 baseline normalized for weather and production. In 2012, we improved global energy efficiency by 6.4 percent against a 2011 year baseline normalized for weather and production levels.

We reduced our overall facilities-related $CO_2$ emissions by approximately 47 percent, or 4.65 million metric tons, from 2000 to 2012. During this same period, we reduced facilities-related $CO_2$ emissions per vehicle by 37 percent. Our total $CO_2$ emissions increased from 2011 to 2012 by 1 percent, while $CO_2$ emissions per vehicle decreased by 1 percent during that period.[1]

The Company has met its commitment to reduce U.S. facility emissions by 10 percent per vehicle produced between 2002 and 2012, as part of an Alliance of Automobile Manufacturers program.

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

## Energy Management Initiatives

Ford has achieved these efficiency improvements and energy-use reductions using the variety of initiatives 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.

Since 2007, we have been using a utility metering and monitoring system to collect electricity and natural gas consumption data at the plant level for all Ford plants in North America. We are currently expanding this system, called the Global Departmental Level Metering (GDLM) initiative, globally and working to provide 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 commonizing the Building Management Systems we use at our facilities. These information management initiatives will provide common reporting tools linked with production and other data sets, and 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.

We are also continuing to roll out an Energy Management Operating System (EMOS), which is aligned with our Ford Production System (FPS) and ISO 14000/50001 principles. The EMOS leverages existing lean manufacturing principles, incorporates Plan-Do-Check-Act (PDCA) protocols and uses Six Sigma tools. We developed our EMOS using a cross-functional approach that includes multiple disciplines and all operating regions of the Company. 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 provides a common and global structure to support and maintain energy-reduction changes, to achieve the corporate goal of improving global energy use per vehicle by 25 percent between 2011 and 2016.

The EMOS is divided into four major sections:

- Plant Energy Teams – primary engagement with facilities and occupants to effect change
- Facility Changes – planning for the future (both facility and process) and getting the standards embedded into future product/project plans
- Data Management – ensure robust data for reporting and analysis
- Energy Supply and Quality – ensure reliable and low cost energy

We are currently rolling out the EMOS as part of our expanded FPS, including establishing a standardized format for Plant Energy Team meetings, Plant Energy Roadmaps, Energy Health Assessments and Energy Reporting.

In North America, Ford continues to use energy performance contracting as a financing tool to upgrade and replace infrastructure at its 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 2012, we upgraded the lighting at several of our commercial, research and manufacturing facilities through “Mega Lighting” performance contracts. These upgrades included replacing old lighting technologies with high-efficiency (T8 and T5H) fluorescent lighting. As a result, we have reduced annual energy consumption at these buildings by 11.5 million kWh. We are developing other “Mega Lighting” projects for eight additional manufacturing sites, which we predict will reduce our annual electricity consumption by another 5 million kWh. 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 $246 million in plant and facility energy-efficiency upgrades. In 2012 alone, we invested more than $20 million in energy-efficiency or related upgrades to our global manufacturing base. 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.

We are continuing to replicate Ford’s state-of-the-art “Three-Wet” paint process. This technology is called “Three-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 Three-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, Three-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, Three-Wet reduces paint processing time by 20 to 25 percent, which correlates to a significant cost reduction. The paint formulation contains new polymers and other additives to prevent running and sagging during the application and curing processes. 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, reduced $CO_2$, improved energy efficiency and improved quality.

Ford initially implemented the Three-Wet process at our Ohio Assembly Plant 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 Three-Wet paint process at facilities in the United States, India, Romania, Mexico, China and Thailand. We now use the Three-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 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.

We are also continuing to refine our Paint Emissions Concentrator (PEC) system (formerly referred to as "fumes to fuel,") which reduces the $CO_2$ emissions associated with our paint shop emissions-treatment process. In traditional paint shop emissions treatment, the volatile organic compound (VOC) emissions from solvent-based paints are captured and destroyed in a regenerative thermal oxidizer using natural gas as a fuel. Our PEC technology concentrates VOC emissions from the painting process by approximately 1,500:1. In this super-concentrated state, the VOCs can be burned as a fuel source, significantly reducing the amount of natural gas necessary to destroy them. By reducing the need for natural gas, the PEC system has the potential to reduce $CO_2$ emissions by 70 to 80 percent, compared to traditional abatement equipment. We are also investigating opportunities to reform super-concentrated VOCs into hydrogen, which can then be used as a fuel source for a fuel cell. For more information on the PEC technology, please see the Facilities-Related Emissions section.

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

- aggressively curtailing energy use during nonproduction periods,
- updating facility lighting systems by replacing inefficient high-intensity discharge fixtures with up-to-date fluorescent lights and control systems, and
- installing automated control systems on plant powerhouses and wastewater treatment equipment to increase energy and process efficiency.

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1. Total $CO_2$ emissions from facilities increased slightly from 2011 to 2012 due to increases in production. However, $CO_2$ emissions per vehicle decreased slightly, reflecting greater efficiency.

# Renewable Energy

## Ford is actively involved in the installation, demonstration and development of alternative sources of energy.

Ford's Dagenham Diesel Engine Assembly line in the UK was the first automotive plant in the world to obtain all of its electrical power 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 Wales, Ford's Bridgend Engine Plant was the first site retrofitted with one of the largest integrated, grid-connected solar/photovoltaic installations at a car manufacturing plant in Europe.

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 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 itself back in four years.

# 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 more than 35 percent. In 2012, these operations emitted 18 grams of VOCs per square meter of surface coated, down from 20 grams in 2011. 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 PEC system was first developed at a research facility we built at our assembly plant in Oakville, Canada, in 2008 with support from the Canadian government. The site contains a production-scale version of the equipment. 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. In 2012, the PEC at our Oakville facility continued to run and generate solvent, allowing for the capture and recycling of 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 "Three-Wet." This process reduces VOC emissions by 10 percent and has other environmental, financial and quality benefits. For more information on Three-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 consumer, 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.

## Related links

This Report

- Water

Climate Change and the Environment

- Design for Lifecycle Sustainability
- Climate Change
- Greening Our Products
- Greening Our Operations
  - Operational Energy and Greenhouse Gas Emissions
  - Non-$CO_2$, Facility-Related Emissions
  - Water Use
  - Waste Management
  - Sustainable Land Use and Biodiversity
  - Green Buildings
  - Compliance
  - Remediation
- Data
- Voice: Mark Lee

# 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 by-products 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 2012, Ford facilities globally sent approximately 50.6 metric tons of waste to landfill, a reduction of 17.4 percent from 2011.

In 2012, Ford facilities globally generated approximately 42,000 metric tons of hazardous waste, which is comparable to our 2011 hazardous waste-generation levels. We reduced hazardous waste on a per-vehicle basis by 2.6 percent compared to 2011 and by 19.6 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 new 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

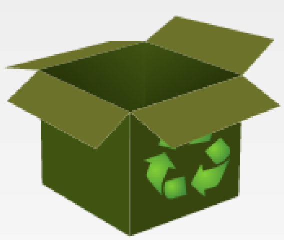
**Identify**
Identify the five largest volume sources of waste- to-landfill at each facility

**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

### 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**

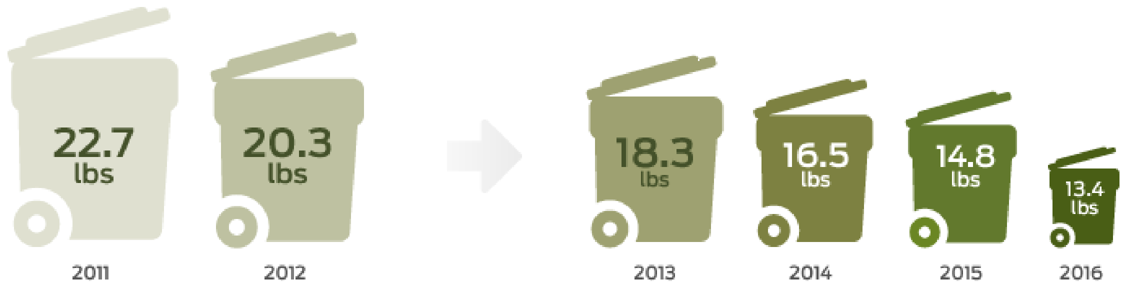
Van Dyke Transmission became a zero waste-to-landfill plant, helping cut the amount of waste-to-landfill generated per vehicle globally to 20.3 pounds in 2012

### Progress

Ford cut the amount of waste-to-landfill generated per vehicle globally from 38 pounds in 2007 to 22.7 pounds in 2011

### Goal

By 2016, Ford will reduce pounds of waste-to-landfill generated per vehicle globally to 13.4 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 tracking 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 zero waste to landfill:

- JMC Transit
- Chennai Assembly
- Lio Ho Assembly
- Genk Assembly
- Cologne Assembly
- Saarlouis Assembly
- Essex Engine
- Van Dyke Transmission
- Cologne Engine
- Cologne Die Cast
- Cologne Catarko Forging
- Chennai Engine
- JMC Engine
- Windsor Engine
- Ford Thailand Manufacturing

Some other successes of our waste-reduction efforts in 2012 include the following:

- We have recycled 710 tons of Recovered Paint Solids (RPS) from the Ford Flat Rock Assembly Plant in Flat Rock, Michigan, the Ford Michigan Assembly Plant in Wayne, Michigan, and the Chicago Assembly Plant in Chicago, Illinois, since early 2010. An estimated 710,000 KWh of energy – enough energy to power 87 residential homes for a year – were produced as a direct result of this program. The RPS replaced approximately 426 tons of coal at DTE, a local energy company.
- Our Broadmeadows Assembly Plant achieved a 35 percent decrease in waste to landfill, in part through recycling wastewater treatment plant “filter cake” and phosphate sludge.
- Our Cuautitlan Assembly Plant achieved a 59 percent decrease in waste to landfill in part by implementing an aggressive program for the identification, segregation and recovery of different plastic wastes; 100 percent recycling of cardboard; and changing other waste streams from landfill to co-processing disposal.
- Our Kentucky Truck Plant achieved a 22 percent decrease in waste to landfill in part by implementing a single-stream recycling program that resulted in almost 1 million pounds of recyclables being diverted from landfill disposal.
- Our Lima Engine Plant achieved a 55 percent decrease in waste to landfill in part by recycling eight-foot-long, 350-pound fabric coolant filters.
- Our Livonia Transmission Plant achieved a 74 percent decrease in waste to landfill in part by disposing of some waste through waste-to-energy programs.
- Our Pacheco Assembly Plant achieved a 78 percent decrease in waste to landfill by implementing improved waste segregation methods.
- Our Camacari Plant achieved a 44 percent decrease in waste to landfill, and 100 percent

of organic waste is now composted.

# 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, as follows.

## Sustainable Landscapes

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.

In 2012, we began recycling 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 were able to add more than 3,000 cubic yards of nutrient-rich compost to our fields in lieu of a synthetic, petroleum-based fertilizer.

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, evapo-transpiration rates and local weather data – to program watering only when it is needed. To date, systems at 35 sites have been completed and are providing water savings of just over 30 percent. Systems at an additional 12 sites will be completed this year, with the remaining 28 sites to be completed over the next three years.

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 planning to replace a portion of its vehicle fleet with propane autogas fueled units. They are also in the process of adding an on-site propane fueling station for trucks and mowers.

## Creating Wildlife Habitat

Ford has created wildlife habitats at many of our facilities. We are committed to maintaining our existing wildlife habitat sites and to creating as many new sites as possible in the future. Wildlife habitats on Ford facilities range in size from five acres to more than 100 acres and include ecosystems as diverse as wetlands, woodlands, prairies, meadows and forests. Ford employees, often in partnership with local civic and education groups, develop and maintain the habitats, which host dozens of native plant and wildlife species. At many of the facilities, employees and other volunteers have built nature trails, erected bird and bat houses and planted wildflower gardens, in addition to establishing wildlife habitats. These facilities have also developed community education programs to encourage broader understanding of the importance of corporate wildlife sanctuaries.

In Europe, we have created large natural reserves at our facilities in Valencia, Spain, and Kocaeli, Turkey.

Our Mexican operations and dealers are also working to protect wildlife habitat and biodiversity. Since 1997, our Mexican operations have supported a Peninsular Pronghorn protection program. The Peninsular Pronghorn is an endangered species that lives only in the Baja California Peninsula. The program protects this species from hunting, depredation and the impoverishment of its natural habitat. After many years of effort, a captive population of the Pronghorn grew in size, and now they have been returned to their natural habitat. The program finished in May 2012.

Since 2007, Ford of Mexico and its dealers have been committed to promoting the importance of preserving protected areas through a communication project to inform and raise public awareness about the importance of biodiversity. The project, which included the production of video clips, printed articles and advertisements about seven major ecosystem types in Mexico (deserts, forests, rainforests, mountains, islands, reefs and wetlands), finished in December 2011. Ford of Mexico's Civic Committee is currently working to identify and implement a new environmental program.

# 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, lifecycle 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. Some examples of best engineering practices that will 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
- 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 and Operations 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 Building 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 evaluating the certification of the balance of our portfolio of commercial office buildings through the USGBC's LEED for Existing Buildings: Operations and Maintenance Volume program. 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.

Related links

This Report

- Dealers

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.

In 2012, Ford installed porous pavement systems in the parking areas of our Louisville Assembly Plant in Louisville, Kentucky. These systems reduce the amount of stormwater that runs off the site and into municipal storm sewer systems by allowing rainwater to infiltrate through porous pavement blocks and into the ground below. This project will help to reduce high flows in combined storm and sewage sewer systems during storm events and the resulting potential for sewage overflows into local stream and river systems. This project received an award from Ford's Environment Quality Office in 2012. We also use porous pavement systems at our Rouge Plant in Dearborn, Michigan, as described below.

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:

### 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 nonhazardous 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 bio-swales 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 multi-screen theaters and an observation deck. The facility uses rainwater for plumbing and irrigation, and 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.

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# Compliance

## Manufacturing Plants Notices of Violation

Ford received three notices of violation (NOV) from government agencies in 2012. Two NOVs were in the U.S. and one was in Canada. 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.

## Offsite Spills

In 2012, no off-site spills occurred at Ford manufacturing facilities.

## Fines and Penalties Paid

In 2012, 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, including the adequacy of the prior investigation and cleanup. The Ringwood site was initially an iron mine owned most recently by the United States, and subsequently used for decades for disposal of a wide variety of wastes by residents and local governments. Ford used the site to dispose of waste materials (primarily cardboard, wood wastes and paint sludge from the former Mahwah Assembly Plant) from 1967 to the middle of 1971. Ford participated in remediation activities at the site in the 1980s and 1990s. In September 2004, Ford entered into an Administrative Order on Consent (AOC) and Settlement Agreement with the U.S. Environmental Protection Agency (EPA) regarding additional environmental activities at the Ringwood site. Ford entered into a second AOC with the EPA in May 2010 that obligates Ford to complete the remedial site investigations, human health and ecological risk assessments, as well as feasibility studies for each of the three soil operable units (OUs) and one groundwater OU. Ford, with the Borough of Ringwood's cooperation, is currently completing the necessary reports for the three soil OUs. It is anticipated that the EPA will select a final remedial approach for the three soil OUs later this year and construction could begin in late 2014 or early 2015.

# Data

IN THIS SECTION

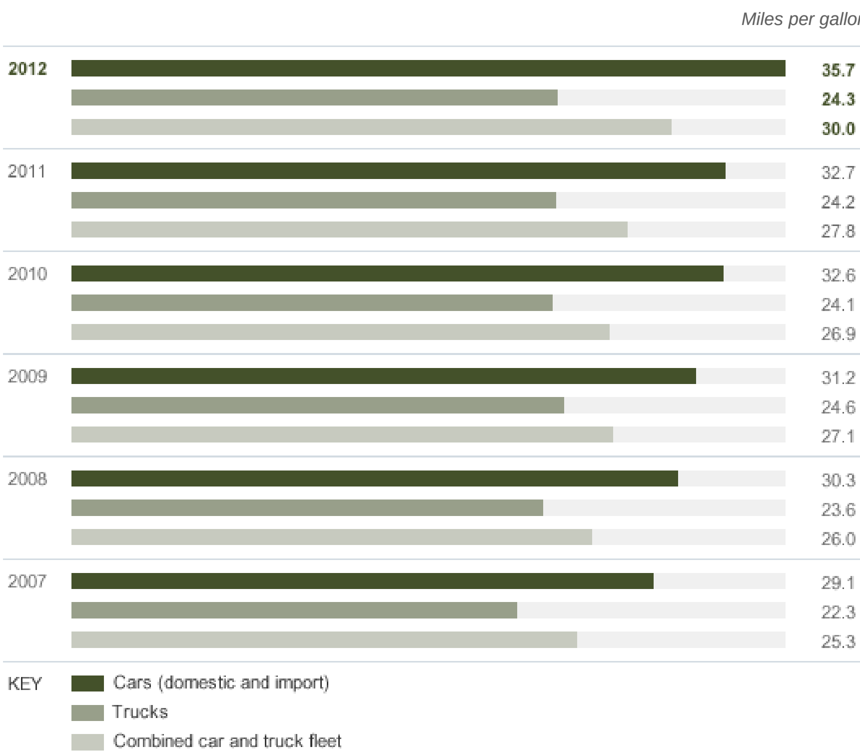
Data:

# Fuel Economy and $CO_2$ Emissions

## DATA ON THIS PAGE



## A. Ford U.S. Corporate Average Fuel Economy




| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| Cars (domestic and import) | 29.1 | 30.3 | 31.2 | 32.6 | 32.7 | 35.7 |
| Trucks | 22.3 | 23.6 | 24.6 | 24.1 | 24.2 | 24.3 |
| Combined car and truck fleet | 25.3 | 26.0 | 27.1 | 26.9 | 27.8 | 30.0 |

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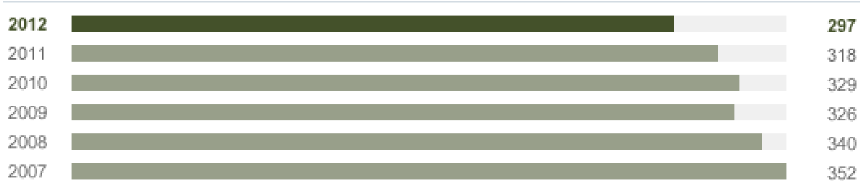
## B. Ford U.S. $CO_2$ Tailpipe Emissions per Vehicle (Combined Car and Truck Fleet Average $CO_2$ Emissions)

*Grams per mile*




| 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|
| 352 | 340 | 326 | 329 | 318 | 297 |

### Notes to Data

Improvement is reflected in decreasing grams per mile. This is the first year that the CO2 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 CO2 value includes FFV credits, but does not include credits/debits for air conditioning or off-cycle technologies or CH4/N2O compliance.

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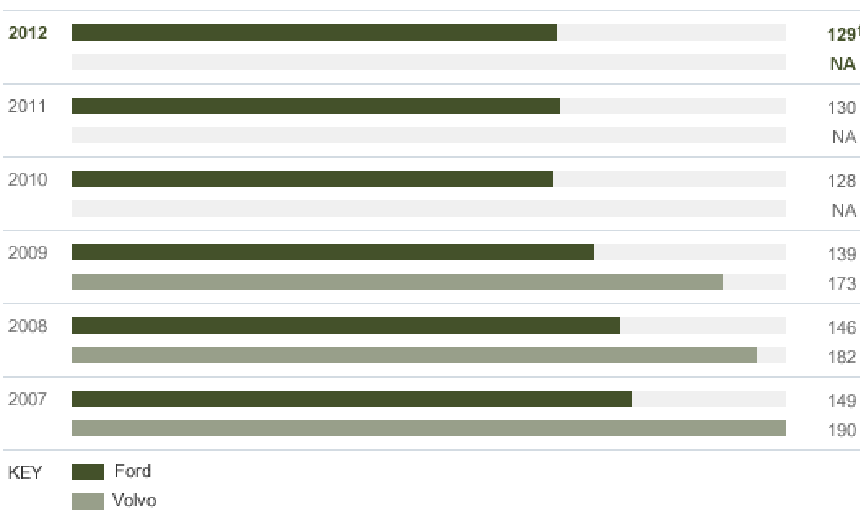
## C. Ford Europe $CO_2$ Tailpipe Emissions per Vehicle

*Grams per kilometer*




| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| Ford | 149 | 146 | 139 | 128 | 130 | 129 [1] |
| Volvo | 190 | 182 | 173 | NA | NA | NA |

### Notes to Data

1. This is preliminary data; official data from European Commission expected in November 2013.

Improvement is reflected in decreasing grams per kilometer. 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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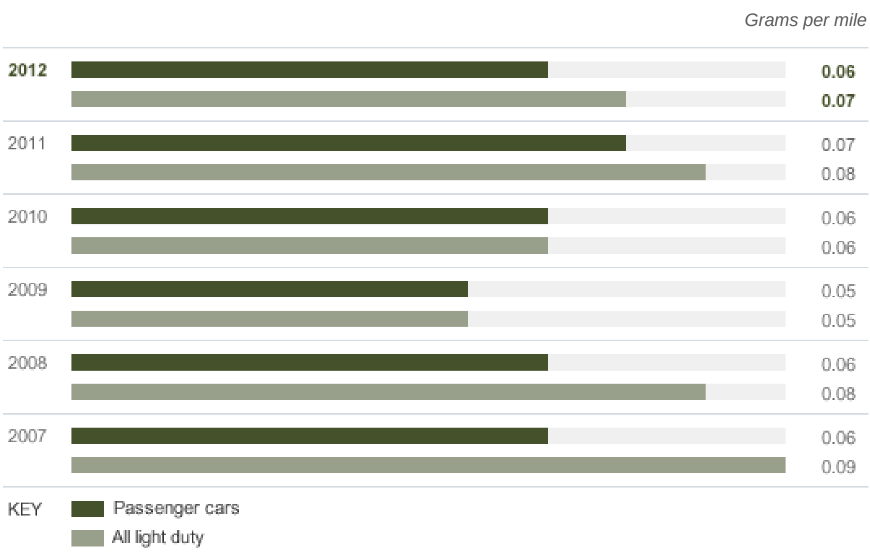
Data:

# Tailpipe Emissions

DATA ON THIS PAGE



## A. Ford U.S. Average NOx Emissions




| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| Passenger cars | 0.06 | 0.06 | 0.05 | 0.06 | 0.07 | 0.06 |
| All light duty | 0.09 | 0.08 | 0.05 | 0.06 | 0.08 | 0.07 |

Reported to regulatory authorities (EPA)

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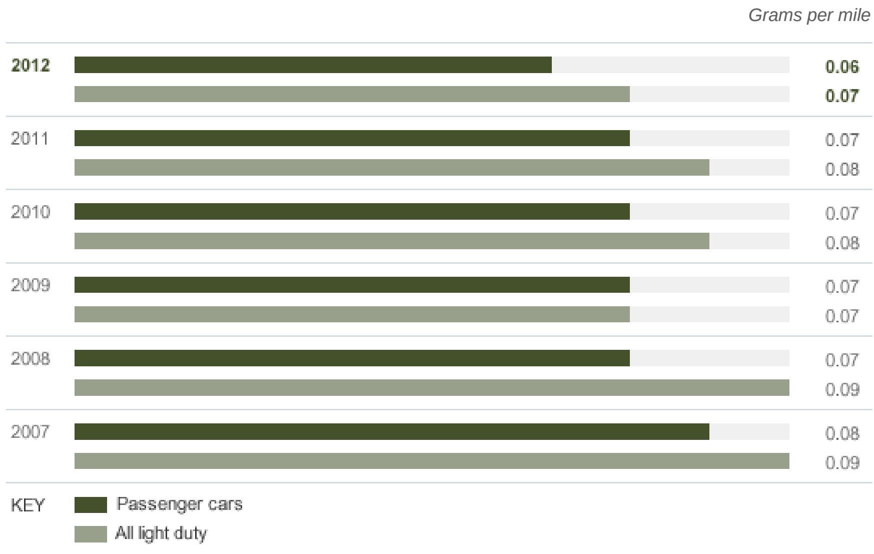
## B. Ford U.S. Average NMOG Emissions




| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| Passenger cars | 0.08 | 0.07 | 0.07 | 0.07 | 0.07 | 0.06 |
| All light duty | 0.09 | 0.09 | 0.07 | 0.08 | 0.08 | 0.07 |

Reported to regulatory authorities (EPA)

### Notes to Data

NMOG = Non-Methane Organic Gases

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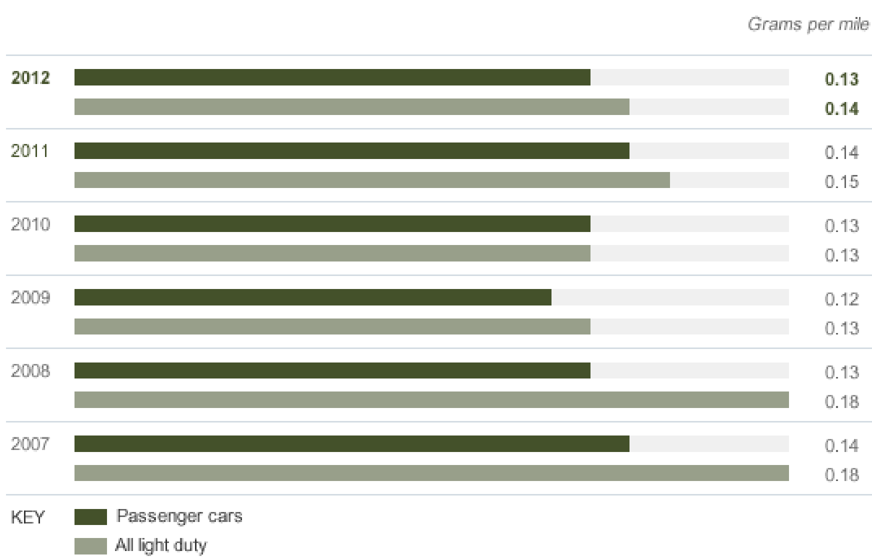
## C. Ford U.S. Average Vehicle Emissions



| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| Passenger cars (Grams per mile) | 0.14 | 0.13 | 0.12 | 0.13 | 0.14 | 0.13 |
| All light duty (Grams per mile) | 0.18 | 0.18 | 0.13 | 0.13 | 0.15 | 0.14 |
| Fleet Reduction (M Lbs) | NA | NA | NA | NA | -27.10 | -27.5 |

Reported to regulatory authorities (EPA)

## Notes to Data

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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  - Waste
- Voice: Mark Lee

Data:

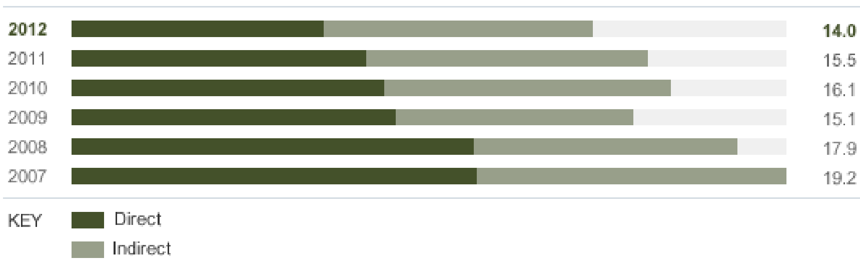
# Operational Energy Use and $CO_2$ Emissions

**DATA ON THIS PAGE**



## A. Worldwide Facility Energy Consumption

*Billion kilowatt hours*




| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| Direct | 10.9 | 10.8 | 8.7 | 8.4 | 7.9 | 6.8 |
| Indirect | 8.3 | 7.1 | 6.4 | 7.7 | 7.6 | 7.2 |
| Total | 19.2 | 17.9 | 15.1 | 16.1 | 15.5 | 14.0 |

Data managed through the Global Emissions Manager database

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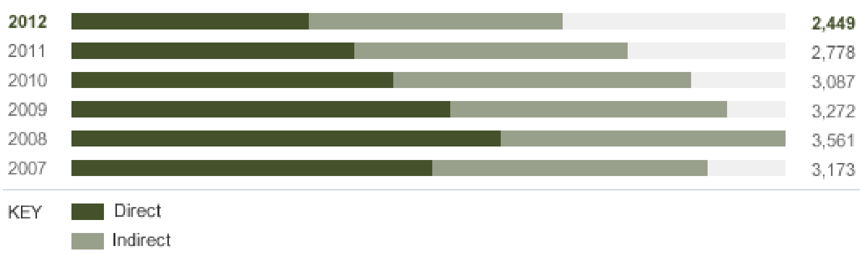
## B. Worldwide Facility Energy Consumption per Vehicle

*Kilowatt hours per vehicle*




| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| Direct | 1,804 | 2,142 | 1,891 | 1,609 | 1,408 | 1,186 |
| Indirect | 1,369 | 1,419 | 1,381 | 1,478 | 1,370 | 1,263 |
| Total | 3,173 | 3,561 | 3,272 | 3,087 | 2,778 | 2,449 |

Data managed through the Global Emissions Manager database

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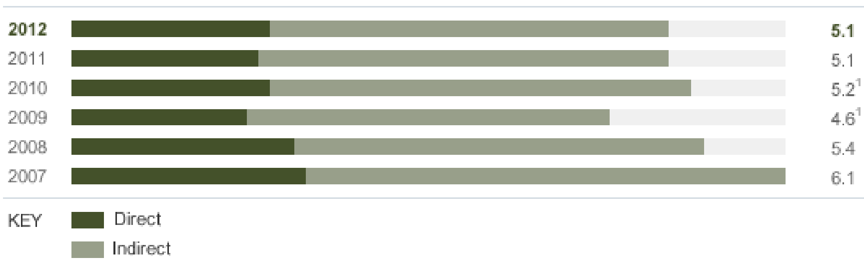
## C. Worldwide Facility $CO_2$ Emissions

*Million metric tons*




| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| Direct | 2.0 | 1.9 | 1.5 | 1.7 | 1.6 | 1.7 |
| Indirect | 4.1 | 3.5 | 3.1 | 3.6 | 3.5 | 3.4 |
| Total | 6.1 | 5.4 | 4.6 [1] | 5.2 [1] | 5.1 | 5.1 |

Third-party verified (North America and EU)[2]

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.

### Notes to Data

1. We restated our 2009 and 2010 worldwide facility $CO_2$ emissions because the universe of facilities used to calculate worldwide facility $CO_2$ emissions was modified.
2. Over two-thirds of Ford's global facility greenhouse gas (GHG) emissions are third-party verified. From 1998-2010, all of Ford's North America GHG emissions data were externally verified by FINRA, the auditors of the NASDAQ stock exchange, as part o our membership in the Chicago Climate Exchange. Beginning in 2011, all of Ford's North American GHG emissions are now also verified under The Climate Registry, a nonprofit collaboration among North American states, provinces, territories and

Native Sovereign Nations that sets consistent and transparent standards to calculate, verify and publicly report greenhouse gas emissions into a single registry. In addition, all emissions data covered by the EU Emission Trading Scheme (EU-ETS) and voluntary UK Climate Change Agreements are third-party verified. All EU-ETS verification statements are provided to Ford by facility from BSI for UK facilities, Lloyds for Spain and the Flemish Verification Office for Belgium. North American facilities are verified against The Climate Registry's General Reporting Protocol. European facilities are verified against the EU-ETS rules and guidelines.

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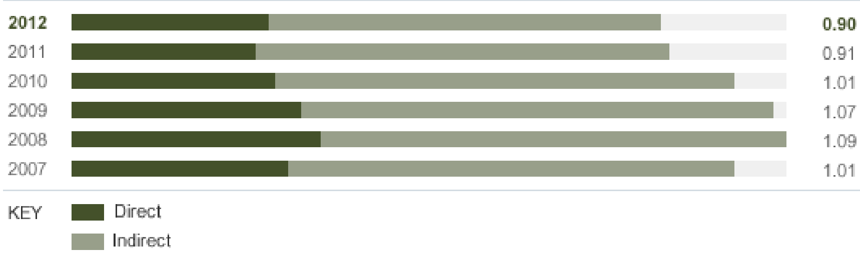
# D. Worldwide Facility $CO_2$ Emissions per Vehicle

*Metric tons per vehicle*




| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| Direct | 0.33 | 0.38 | 0.35 | 0.31 | 0.28 | 0.30 |
| Indirect | 0.68 | 0.71 | 0.72 | 0.70 | 0.63 | 0.60 |
| Total | 1.01 | 1.09 | 1.07 | 1.01 | 0.91 | 0.90 |

Data managed through the Global Emissions Manager database

## Notes to Data

$CO_2$ emissions per vehicle declined for the fifth year, reflecting our focus on improving the energy efficiency of our operations. We are workging to meet our goal of reducing global facility $CO_2$ emissions per vehicle by 30 percent by 2025 from a 2010 baseline.

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# E. Energy Efficiency Index

*Percent*

| 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|
| 4.3 | 11.7 | 18.3 | 14.4 | 2.6 | 6.4 |

## Notes to Data

The energy efficiency index is a normalized indicator of energy used 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.

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Voice: Mark Lee

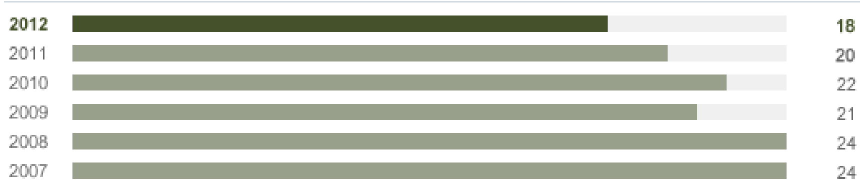
Data:

# Emissions (VOC and Other)



## A. North America Volatile Organic Compounds Released by Assembly Facilities

*Grams per square meter of surface coated*




| 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|
| 24 | 24 | 21 | 22 | 20 | 18 |

Data managed through the Global Emissions Manager database

### Analysis

VOC emissions in North America decreased by 11.7 percent between 2011 and 2012; 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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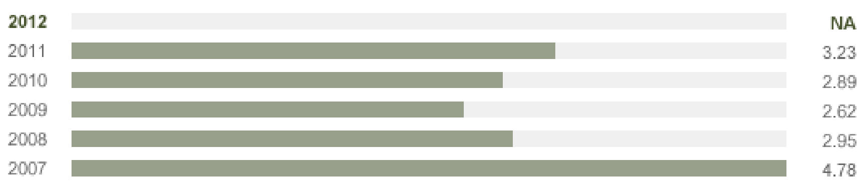
## B. Ford U.S. TRI Releases

*Million pounds*




| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| | 4.78 | 2.95 | 2.62 | 2.89 | 3.23 | NA |

Reported to regulatory authorities (EPA)

### Notes to Data

Releases reported under the U.S. Toxics 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.

### Analysis

Our U.S. Toxic Release Inventory releases increased from 2010 to 2011, due to an increase in production. However, U.S. TRI releases per vehicle decreased in this timeframe, reflecting more efficient production.

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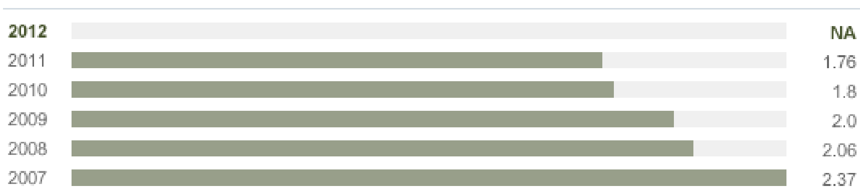
## C. Ford U.S. TRI Releases per Vehicle

*Pounds per vehicle*




| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| | 2.37 | 2.06 | 2.0 | 1.8 | 1.76 | NA |

### Notes to Data

Releases reported under the U.S. Toxics 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.

### Analysis

Our U.S. Toxic Release Inventory releases per vehicle decreased from 2010 to 2011, the sixth year in a row we have reduced these emissions. These reductions were achieved through material and process changes.

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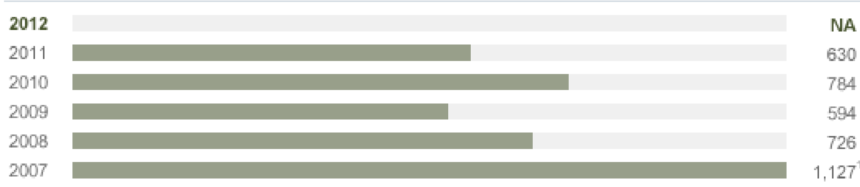
## D. Ford Canada NPRI Releases

*Metric tonnes*




| 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|
| 1,127[1] | 726 | 594 | 784 | 630 | NA |

Reported to regulatory authorities (Environment Canada)

### Notes to Data

1. This figure was restated for our 2011-12 report due to an arithmetic error.

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.

### Analysis

Our Canada National Pollutant Release Inventory releases decreased from 2010 to 2011. These reductions were achieved through material and process changes.

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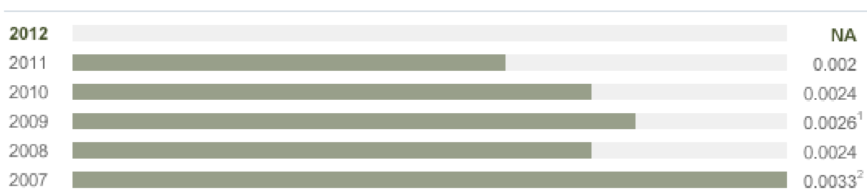
## E. Ford Canada NPRI Releases per Vehicle

*Metric tonnes per vehicle*




| 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|
| 0.0033[2] | 0.0024 | 0.0026 | 0.0024[1] | 0.002 | NA |

### Notes to Data

1. This figure was restated for our 2011-12 report due to an arithmetic error.
2. 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.

### Analysis

Our Canada National Pollutant Release Inventory releases per vehicle continued to decrease from 2010 to 2011. These reductions were achieved through material and process changes.

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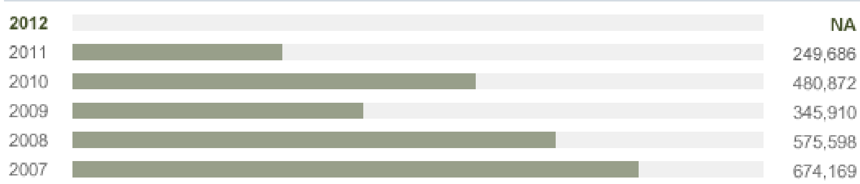
## F. Australia National Pollutant Inventory Releases (Total Air Emissions)

*Kilograms per year*




| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| | 674,169 | 575,598 | 345,910 | 480,872 | 249,686 | NA |

Reported to regulatory authorities (NPI)

### Notes to Data

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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Climate Change and the Environment

- Design for Lifecycle Sustainability
- Climate Change
- Greening Our Products
- Greening Our Operations
- Data
  - Fuel Economy and $CO_2$ Emissions
  - Tailpipe Emissions
  - Operational Energy Use and $CO_2$ Emissions
  - Emissions (VOC and Other)
  - Waste
- Voice: Mark Lee

Data:

# Waste

DATA ON THIS PAGE



## A. Regional Waste to Landfill

*Million kilograms*

Asia Pacific and Africa[1]

| | |
|---|---|
| **2012** | **9.0** |
| 2011 | 8.4 |
| 2010 | 8.2 |
| 2009 | 10.0 |
| 2008 | 9.1 |
| 2007 | 8.5 |

Europe[2]

| | |
|---|---|
| **2012** | **7.7** |
| 2011 | 9.6 |
| 2010 | 11.4 |
| 2009 | 11.7 |
| 2008 | 19.3 |
| 2007 | 19.1 |

North America[3]

| | |
|---|---|
| **2012** | **30.2** |
| 2011 | 36.7 |
| 2010 | 38.6 |
| 2009 | 33.8 |
| 2008 | 43.7 |
| 2007 | 66.1 |

South America[4]

| | |
|---|---|
| **2012** | **3.7** |
| 2011 | 6.6 |
| 2010 | 7.6 |
| 2009 | 7.7 |
| 2008 | 8.8 |
| 2007 | 7.9 |

| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| Asia Pacific and Africa [1] | 8.5 | 9.1 | 10.0 | 8.2 | 8.4 | 9.0 |
| Europe [2] | 19.1 | 19.3 | 11.7 | 11.4 | 9.6 | 7.7 |
| North America [3] | 66.1 | 43.7 | 33.8 | 38.6 | 36.7 | 30.2 |
| South America [4] | 7.9 | 8.8 | 7.7 | 7.6 | 6.6 | 3.7 |

Data managed through the Global Emissions Manager database

## Notes to Data

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.
4. In 2012, waste to landfill was restated for 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.

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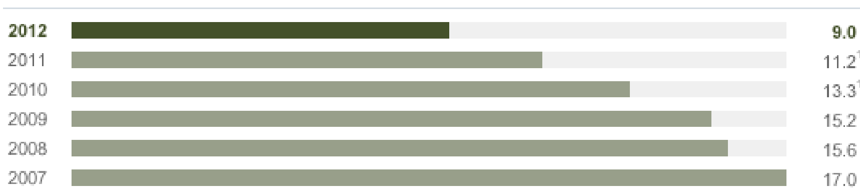
# B. Waste to Landfill per Vehicle

*Kilograms*




| 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|
| 17.0 | 15.6 | 15.2 | 13.3 [1] | 11.2 [1] | 9.0 |

Data managed through the Global Emissions Manager database

## Notes to Data

1. 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.

## Analysis

In 2012, we reduced waste to landfill on a per-vehicle basis by about 19.6 percent, 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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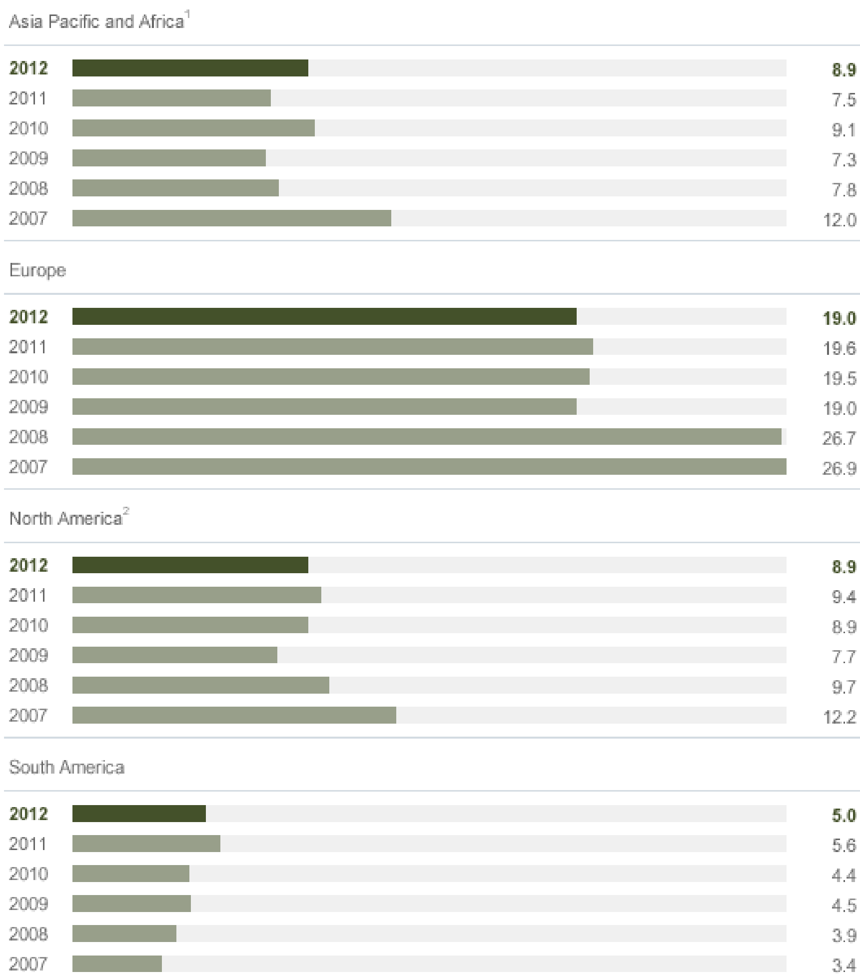
## C. Regional Hazardous Waste Generation

*Million kilograms*




| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| Asia Pacific and Africa[1] | 12.0 | 7.8 | 7.3 | 9.1 | 7.5 | 8.9 |
| Europe | 26.9 | 26.7 | 19.0 | 19.5 | 19.6 | 19.0 |
| North America[2] | 12.2 | 9.7 | 7.7 | 8.9 | 9.4 | 8.9 |
| South America | 3.4 | 3.9 | 4.5 | 4.4 | 5.6 | 5.0 |

Data managed through the Global Emissions Manager database

## Notes to Data

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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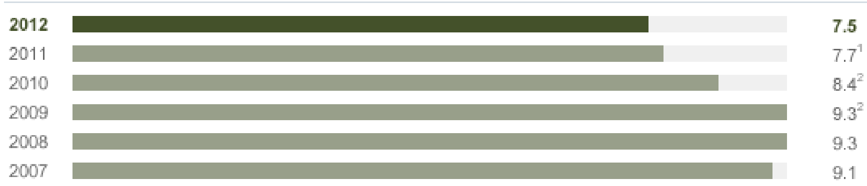
# D. Hazardous Waste Generation per Vehicle

*Kilograms*




| 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|
| 9.1 | 9.3 | 9.3[2] | 8.4[2] | 7.7[1] | 7.5 |

Data managed through the Global Emissions Manager database

## Notes to Data

1. In 2012, hazardous waste per vehicle data was restated for 2011 to correct for misclassifications in disposal and recycling codes
2. In 2011, hazardous waste to landfill data for 2010 and 2009 was restated due to corrections in the data.

## Analysis

In 2012, we continued a five-year improvement trend by reducing hazardous waste on a per-vehicle basis by 2.6 percent.

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# Mark Lee

## Executive Director
## SustainAbility

Nearly all the climate data coming at us reveal accelerating negative trends. The 13 hottest years on record have all occurred since 1998. The International Energy Agency says we're now at risk of locking in irrevocable climate change impacts by as early as 2017 and probably no later than 2022. Yet, we're not getting responses from national governments, and we have had very few strong responses from the markets. Investors, for example, do remarkably little to price carbon risk into their investments.

Industry thus far has relied heavily on a model of voluntary practices; I wonder if we're at a point where the limits of that model are being breached. We live in an "age of acknowledgment" in which increasing numbers of companies and private-sector leaders recognize and state sustainability challenges, from climate change to biodiversity, but don't do enough about them. In too many cases, corporate responsibility reporting, coupled with eco-efficiency, is seen as enough, leaving us awash in companies setting relative performance improvement targets rather than committing to absolute shifts. Also, we're still completely embedded in the good and bad of the fossil fuel energy system – from the real economic and social benefits to the enormous negative of global warming due to greenhouse gas emissions. To make progress, we'll have to replace the economic and social benefits that fossil fuel use provides while dramatically diminishing its ecological harm.

The big question, then, is how to enable business to make the changes this planet needs. I think there are some remarkable efforts out there, including Ford's development of a product plan that is based on stabilizing atmospheric carbon dioxide ($CO_2$) concentration at 450 parts per million (ppm), along with pledges made by consumer product companies and apparel makers, among others.

Companies need to step back and look holistically at climate change and the full range of impacts it can have on a business, from sourcing to production to consumer relationships to end-of-life issues. Companies also must think about climate change as much more than an environmental issue. It's a moral issue, a political issue and, of course, a business issue, and it's unproductive to try to isolate climate in just one of those categories.

It's worth noting that it isn't all doom and gloom, and we shouldn't overlook any pieces of good news. For example, between 2007 and 2012, there was a more than 6 percent decline in U.S. greenhouse gas emissions. And, yes, people will say that this was during a period of recession, which is true. But diminished economic productivity was not nearly the whole story, and we have to learn from and scale what was done right during this period.

My relationship with Ford, which has spanned well over a decade and more than one professional role for me personally, has given me a unique perspective into the automaker. Ford definitely stands out among a wave of early adopters that embraced a sustainability agenda even as the idea of sustainable development was still emerging.

This was partly due to the leadership of Bill Ford. But other striking examples were Ford's early decision to leave the Global Climate Coalition, and the Company's back-of-the-envelope calculation, in the early 2000s, about the direct and indirect climate impact of its operations and production. Ford's willingness to explore the data and understand its role in the global debate was powerful in and of itself, and its willingness to publish that information helped shift the conversation.

The greatest testament, to me, however, is the Ford product plan based on stabilizing atmospheric $CO_2$ concentration at 450 ppm mentioned previously. People can argue about whether 450 ppm is the right number and worry about whether everyone else is aligning their businesses in a similar way. But Ford's plan is nonetheless light-years beyond where most others are in terms of putting their operations and impact in a larger economic and societal context.

Outside the environmental arena, Ford has consistently been a leader around human rights and labor rights – for instance, its early support of the United Nations Global Compact set it apart from its peers. This isn't to say that all is perfect under the Blue Oval. But it does leave me thinking that sustainability has come to be baked into everything Ford does.

One aspect that Ford and others can improve upon is shaping consumer demand. While I understand how incredibly difficult it is to influence consumer fancy, I'm concerned that Ford and other companies let the markets dictate production volumes of more sustainable products. The issues we face are too serious to leave entirely to the whims of consumers. Companies spend enormous sums of money on advertising, so they obviously must feel they can influence consumer choices. From a sustainability perspective, we need companies to deliver increasing numbers of more sustainable products – and we need consumers to buy them.

Another challenge is that more than 50 percent of our planet already lives in urban locations, and that we will be about 70 percent urban, as a species, by mid-century. Ford has flirted with the development and delivery of a comprehensive urban mobility platform over the years and has been on the edge of breakthrough leadership, but neither Ford nor anyone else in the industry has yet seized on this and made it their own. I'd love to see Ford and the industry push harder at the system challenges in the ways that will be necessary to deliver the accessible, affordable, low-carbon mobility system required.