# Sustainable TRANSPORTATION

**Office of Energy Efficiency and Renewable Energy**
U.S. Department of Energy

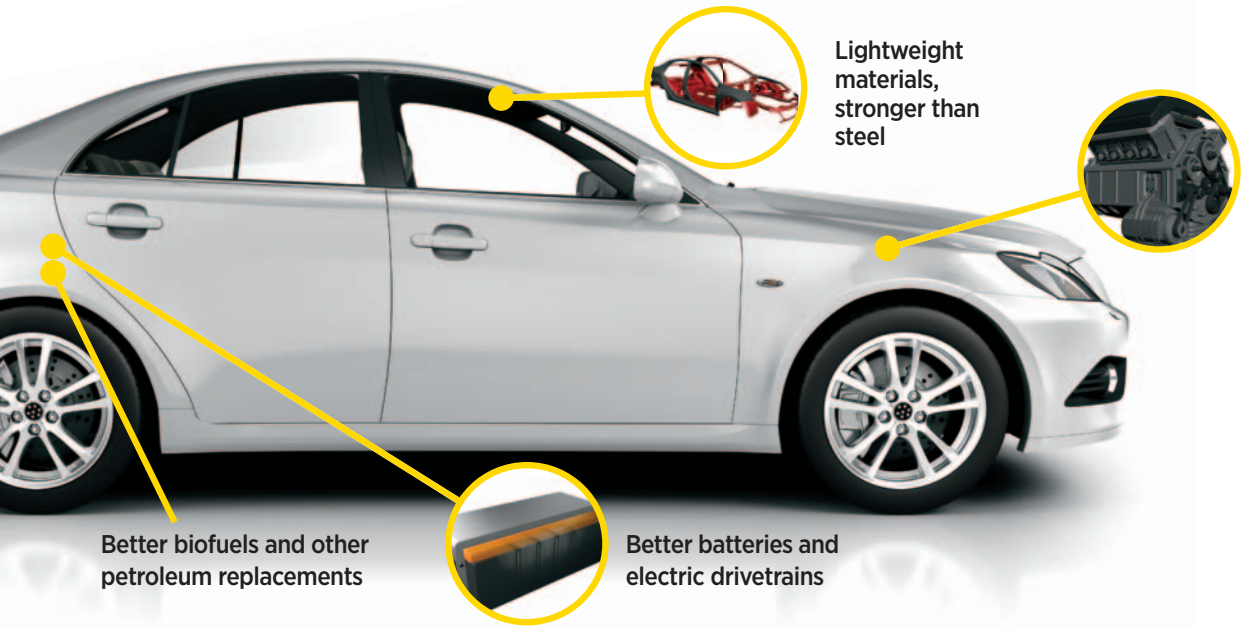
The United States sends other countries almost $1 billion each day for oil to power our cars, trucks, planes, trains, and ships. In addition, estimates have shown that emissions cause more than $55 billion per year in health and other damages, and vulnerability to unexpected increases in oil prices costs an additional $45 billion per year[1]. Advances in electric vehicles, engine efficiency, and clean domestic fuels open up cost-effective opportunities to reduce our oil dependence, avoid pollution, and create jobs designing and manufacturing better cars, trucks, and petroleum alternatives. In the Office of Energy Efficiency and Renewable Energy (EERE), part of the U.S. Department of Energy (DOE), we manage our portfolio to deliver these many benefits to support America's "all of the above" energy strategy. Recent successes include:

- **Cars and Trucks:** Reduced electric vehicle battery production costs by 35% since 2008[2]. Pioneered better combustion engines that have saved billions of gallons of petroleum fuel and made diesel passenger vehicles as clean as gasoline vehicles[3].
- **Home-grown fuels:** Lowered the cost of non-food-based ethanol by more than $6/gallon since 2001—now projected to be cost-competitive with gasoline priced at $3.20/gallon when ramped up to a commercial scale[4].
- **Fuel cells:** Reduced the cost of manufacturing automotive fuel cells by more than 30% since 2008 and 80% since 2002[5].

## Cars and Trucks

### Reinvigorating U.S. Auto Manufacturing

America is reinventing its auto industry, and DOE is positioning the United States to lead in the global auto market instead of chasing to keep up. In 2009, the United States had only two factories manufacturing advanced vehicle batteries, supplying a mere 2% of the global market[6]. Since then, EERE has supported 30 new advanced battery and electric vehicle component plants that are opening across the country. As a result, by 2015, the United States will be able to produce enough batteries and components to support the production of one million plug-in hybrid and electric vehicles per year[7]. Investments like these help employ tens of thousands of Americans nationwide.




U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

## Making Better, Lower-Cost Batteries

Plug-in hybrid and all-electric cars and trucks are already cheap to operate—the electricity needed to power these vehicles is often equivalent to less than $1 per gallon of gasoline[8]. EERE's work to lower battery costs is making it more affordable to manufacture—and purchase—one of these vehicles. EERE research has helped reduce production costs of automotive lithium-ion batteries by 35% since 2008, and we are on track to meet our goals for 70% cost reduction by 2015 and 88% by 2022[9].

**Nearly every hybrid electric vehicle sold in the U.S. today uses battery technology developed by EERE.**

For example, one of the EERE-funded teams at Argonne National Laboratory developed a unique suite of cathode materials that can pack up to twice as much energy into the same space as conventional cathodes[10]. This technology is now being commercialized by innovative U.S. companies, including EERE research partner Envia, which recently set the world record for energy density with its prototype[11]. This breakthrough will result in smaller and lighter battery cells, potentially lowering the cost to use this technology. It is just one of EERE's successes in developing new battery technologies and bringing them to market. Nearly every hybrid electric vehicle sold in the United States today uses battery technology developed by EERE[12].

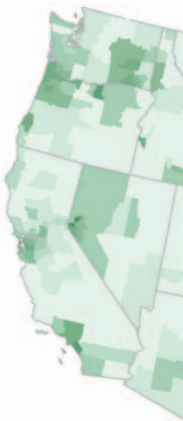
## Boosting Fuel Efficiency with Better Engines, Lighter Vehicles, and SuperTrucks

New fuel economy standards will cut U.S. oil imports by 25% and save families about $8,000 in fuel costs per vehicle by 2025[13]. EERE support has been critical to developing the suite of solutions automakers can use to achieve these benefits while continuing to improve vehicle performance and putting the U.S. automotive industry at the cutting edge of competition:

- **More efficient internal combustion engines** have made diesel passenger vehicles as clean as gasoline ones—and cheaper to drive. We expect future improvements that could cut U.S. transportation fuel use by another 20% to 40%— with matching savings at the pump[14].
- **The next generation of lightweight materials** such as magnesium alloys, high-strength steel, and carbon-fiber composites could reduce passenger car weight by 50%, improving fuel efficiency without compromising performance, safety, or recyclability[15]. Consumers buying a new car with advanced lightweight materials could increase their fuel economy by 35% compared to today's average passenger car fuel economy, an increase which would save more than $4,300 in fuel over the lifetime of the car at today's gasoline prices
- **EERE's SuperTruck initiative will revolutionize on-highway commercial transportation** by improving the freight hauling efficiency of Class 8 trucks by more than 50%. Class 8 trucks are responsible for almost 20% of the country's on-road fuel consumption, and the initiative could save more than $15,000 per truck annually in fuel costs[16].

## Cleaner Fleets, Cleaner Cities

EERE works closely with U.S. businesses to support the adoption of commercial vehicles that run on clean domestic fuels. Through the National Clean Fleets Partnership, we are working with 18 companies—including UPS, FedEx, Coca-Cola, PepsiCo, AT&T, and Verizon—to reduce diesel and gasoline use in their corporate fleets by deploying the alternative fuel vehicles, many of which are among the most high tech available, that best meet the fleets' needs. Together, these fleets operate more than a million cars and trucks nationwide, amounting to more than 25% of all rental and commercial vehicles on American roads. The five founding members have already saved millions of gallons of gasoline and diesel by putting 12,000 alternative fuel vehicles on the road. In addition, Clean Fleets partners have committed to buying more than 50,000 more alternative fuel and advanced vehicles over the next 3 years[17].



EERE also coordinates a network of nearly 100 Clean Cities Coalitions, self-organized groups of local community and business stakeholders whose efforts to adopt smart transportation solutions have replaced more than 3 billion gallons of gasoline and diesel since 1993. These coalitions have been critical to the rapid expansion of the nation's network of alternative fueling stations and electric vehicle charging points[18]. Through the Recovery Act, EERE has built on that foundation—growing the number of U.S. electric vehicle charging stations from 500 in 2009 to over 10,000

**EERE-led efforts have reduced average feedstock logistics costs from $60 per dry ton in 2005 to $38 per dry ton in 2010, equivalent to a reduction of more than $20 per barrel of oil.**

in 2012, and on the way to more than 20,000 by 2013[19].

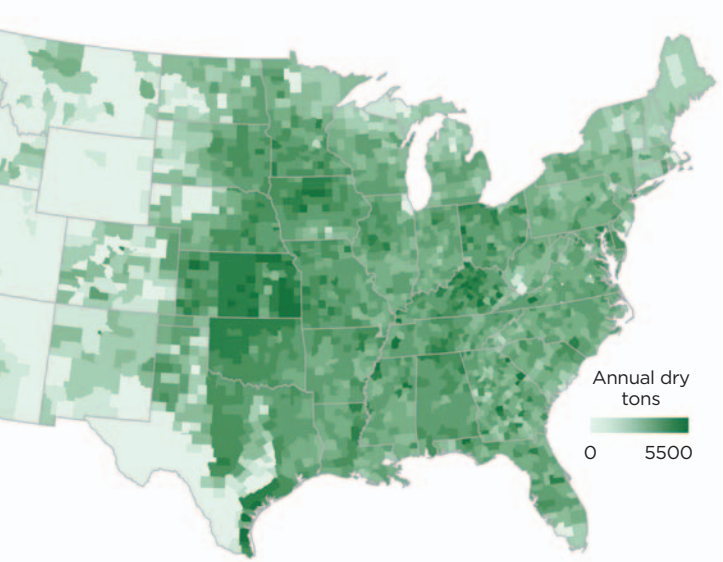
## Homegrown Fuels

Instead of sending $1 billion each day to other countries for oil, we can invest that money in our own economy by "growing" fuels domestically with dedicated non-food crops. These advanced biofuels hold tremendous potential to cut oil consumption well beyond that of our current ethanol supplies, which already replace more than 13 billion gallons of gasoline each year[20], or about 10% of every tank. With our many partners, EERE is building a robust biomass industry that will further reduce petroleum consumption by replacing it with sustainable homegrown fuels.

### Getting Cost-Competitive Fuels from Non-Food Crops

Together with our industry partners, EERE has successfully invested in R&D to make cellulosic ethanol (fuel from trees, grasses, and agricultural wastes) competitive with gasoline. Over the past 10 years, breakthroughs in feedstock logistics, pretreatment, enzymes, and fermentation have helped reduce the production cost of cellulosic ethanol by more than $6 per gallon, making it cost-competitive with gasoline at $3.20 per gallon when ramped up to commercial scale[21].

### Bioenergy Feedstock Resource Potential




Potential county-level resources at $60 per dry ton or less in 2030, under baseline assumptions.
Source: U.S. Billion Ton Update, 2011

To date, four commercial biorefineries—as well as five pilot plants and one demonstration-scale facility—have already broken ground. Together, these projects will be able to produce nearly 100 million gallons of advanced biofuels. These are the first of more than 25 DOE-supported new biorefineries expected to break ground over the next three to four years, validating innovative processes and providing models for commercial production for meeting the goals under the Renewable Fuels Standard[22].


EERE has helped pioneer biobased drop-in replacements for jet fuel.

### Replacing the Whole Barrel of Oil with Drop-In Fuels

Beyond cellulosic ethanol, EERE is developing several ways to make "biocrude" and drop-in fuels that further diversify our nation's fuel supply and enhance energy security. These substitutes for diesel, jet fuel, and home heating oil promise a robust set of options for replacing the whole barrel of oil with sustainable alternatives, grown and processed in the United States. To achieve this goal, EERE is pursuing a portfolio of technical options, including near-term opportunities to convert municipal solid waste, wood, and agricultural residues, as well as longer-term options from algae.

### Better Feedstock Logistics

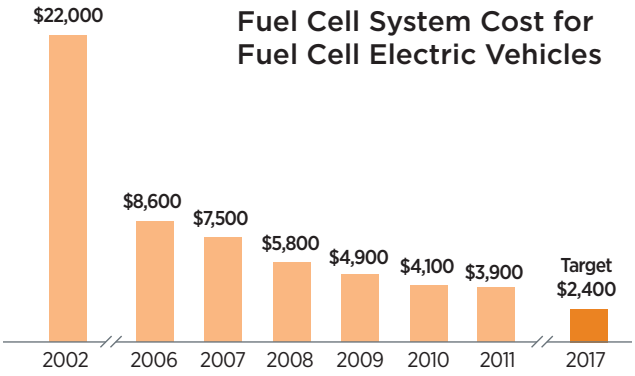
The largest cost for any biorefinery is its raw material feedstock—the wood, the grass, or the waste product it converts to fuel. EERE has made pioneering advances to reduce costs and establish best practices for harvesting, handling, and preprocessing a variety of crops. EERE-led efforts have reduced average feedstock logistics costs from $60 per dry ton in 2005 to $38 per dry ton in 2010, equivalent to a reduction of more than $20 per barrel of oil[23]. Since 2010, we have funded five industry partnerships that are now testing prototypes for commercial harvesting equipment that balances the needs of land owners, feedstock suppliers, equipment manufacturers, and biorefineries. In 2011, we funded Idaho National Laboratory to introduce a mobile user facility to optimize the process of turning bulky crops into pellets and other dense, uniform feedstocks for biofuel and bioenergy production[24]. The success of efforts like these is

accelerating development of cost-effective, high-tonnage feedstock logistics systems that the nation needs to sustain our growing biofuels industry.

## Fuel Cells

Fuel cells efficiently convert fuel into electricity, using clean domestic resources that we can produce in abundance—including hydrogen produced from renewable power, bio-based fuels, and natural gas. Hydrogen from natural gas is already cost-competitive, with gasoline at $3.00 per gallon when produced at high volume. Switching from a gasoline engine to a hydrogen fuel cell could save drivers 6 cents per mile, or more than $700 per year for a typical U.S. driver[25].

**EERE-funded R&D has enabled more than 300 patents and more than 30 commercially available hydrogen and fuel cell technologies.**




Note: Assumes an 80kw fuel cell system and production of 500,000 units per year. Costs projected based on lab-scale advances.

Source: U.S. Department of Energy


### Improving Cost and Performance

EERE's efforts have reduced high-volume manufacturing costs for automotive fuel cells by more than 30% since 2008 and 80% since 2002[26], while doubling durability. EERE has also validated more than 180 fuel cell electric vehicles on the road, logging more than 3.6 million miles. Fuel cells and electric drive powertrains are twice as efficient as gasoline engines, can refuel in less than 5 minutes, and can travel more than 250 miles on a single tank of hydrogen. In fact, in one demonstration a fuel cell vehicle traveled 430 miles without refueling[27].

### Encouraging a Growing Market

EERE's success in bringing new fuel cell technologies to market is converting American innovation into American jobs. EERE-funded research and development has resulted in more than 300 patents, more than 30 new commercial products, and more than 60 emerging technologies. Major companies such as Coca-Cola, FedEx, Wegmans, Sysco, and Whole Foods are deploying fuel cell forklifts in their warehouses and distribution facilities. EERE's cost-sharing in the deployment of about 700 of these forklifts helped validate the market for this early application of motive fuel cells. In the wake of those initial purchases, private businesses have ordered more than 3,500 additional fuel cell forklifts with no Energy Department funding. This rapidly growing market has helped create and keep jobs here in the United States[28].

The Office of Energy Efficiency and Renewable Energy is at the center of creating the clean energy economy today. We lead U.S. Energy Department efforts to develop and deliver market-driven solutions for energy-saving homes, buildings, and manufacturing; sustainable transportation; and renewable electricity generation.

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## Endnotes


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