Innovating energy solutions

Research and development highlights
ExxonMobil invests about $1 billion a year in R&D across all our lines of business.
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ExxonMobil has remained a leader in energy technology throughout its 135-year history. With a commitment to fundamental science and innovation unmatched in our industry, we invest about $1 billion a year in R&D.

We continue to advance a range of technologies to help meet growing demand for energy while also reducing greenhouse gas (GHG) emissions associated with energy use. Our in-house research portfolio includes biofuels, carbon capture and storage, breakthrough energy-efficiency processes, natural gas technologies, advanced energy-saving materials and environmental life cycle assessments. We also work with leading research and technology companies, national labs and universities.

Our commitment to reducing emissions doesn’t stop in the research laboratory. Since 2000, ExxonMobil has spent approximately $8 billion to develop and deploy lower-emission energy solutions across our operations.
ExxonMobil has invested more than $250 million on biofuels research in the past decade. Algae and other advanced biofuels

ExxonMobil is actively researching biofuels made from algae. Algae naturally produce lipids that can be turned into a renewable, lower-emission fuel for transportation. The challenge is doing so economically and at scale, moving this technology from the petri dish to the fuel tank. ExxonMobil and Synthetic Genomics Inc. continue to make progress in identifying and enhancing algae strains capable of high lipid production while maintaining desirable growth rates. And because the manufacturing processes for algae biofuels and today’s transportation fuels are similar, algae biofuels could be processed in existing refineries to supplement supplies of conventional gasoline, diesel and other fuels.

Our broad portfolio of advanced biofuels research also includes biofuels derived from cellulosic biomass. We have an agreement with Renewable Energy Group Inc. to study the production of biodiesel by fermenting cellulosic sugars from sources such as agricultural waste.

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Natural gas technology

Natural gas emits up to 60 percent fewer GHGs than coal for power generation, and is an ideal source of reliable power while also supplementing intermittent renewable energy sources such as solar or wind. It also is an abundant and versatile fuel, capable of powering utilities, homes and transportation. Recent advances in production technologies – many developed by ExxonMobil – have unlocked vast new supplies of gas in North America that previously were uneconomic to produce. **ExxonMobil is the largest natural gas producer in the U.S.**

Increased use of natural gas is a major reason why energy-related CO₂ emissions from the U.S. power sector are down 15 percent since 2010 and at levels not seen since the early 1990s.

ExxonMobil also is a leader in liquefied natural gas (LNG) technology that is bringing more of this cleaner-burning fuel to countries that need it.

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From production to combustion, here are seven important reasons why we think the answer could be yes. Find out why this renewable energy source, which can be grown at scale on a limited amount of land, is so promising.

**ALGAE CONSUME CO₂**

In addition to producing algae, production sites could also act as carbon capture projects.

**LOWERING-EMISSION FUEL**

On a life cycle basis, algae biofuels emit about half as much GHGs as petroleum-derived fuel.

**HIGH YIELD**

Each acre of algae yields more than 2,000 gallons (7,570 liters) of fuel. Compare that to 650 gallons (2,460 liters) per acre for palm oil and 50 gallons (190 liters) per acre for soybean oil.

**YEAR-ROUND HARVESTS**

Unlike other feedstocks, such as corn, which is harvested only once a year, algae can be harvested repeatedly throughout the year.

**FOOD PRODUCTION**

Algae can be cultivated on land unsuitable for other purposes with water that can’t be used for food production.

**WATER PURIFIER**

Algae can be grown in wastewater and industrial effluent, and can actually purify polluted water while simultaneously producing energy-rich biofuels.

**ENGINE READY**

Algae-derived diesel can be pumped into existing diesel automobiles without making major changes to car engines and infrastructure.

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Demand for auto parts, housing materials, electronics and other products made from plastics and other petrochemicals continues to grow. Rising U.S. natural gas production has boosted supplies of ethane, a natural gas liquid raw material used to make plastics, enabling investment in U.S. chemical manufacturing and exports.

Improving industrial energy efficiency and reducing emissions are part of ExxonMobil’s mission to meet the world’s needs while minimizing environmental impacts.

Carbon capture and storage (CCS) is the process by which CO₂ that otherwise would be emitted into the atmosphere is captured, compressed and injected underground for permanent storage. The Intergovernmental Panel on Climate Change has recognized CCS as essential to meeting global emissions-reduction goals.

ExxonMobil remains a leader in CCS technology. Our capacity is among the industry’s largest, with a working interest in about one-fourth of the world’s CCS capacity. In 2016, we captured 6.3 million tonnes of CO₂ for storage – equivalent to switching from coal to gas to meet the electricity needs of about 1 million U.S. homes.

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We are conducting proprietary, fundamental research to develop breakthrough CCS technologies, with an aim to reduce the complexity and cost of this important technology, while increasing its efficiency.
About 40% of global energy-related CO₂ emissions comes from power generation.

ExxonMobil is working with FuelCell Energy Inc. to explore an exciting new possibility: using carbonate fuel cells to more economically capture CO₂ emissions from gas-fired power plants. Existing processes for capturing CO₂ emissions consume energy, which increases costs; but carbonate fuel cells can produce electricity while they capture and concentrate CO₂ streams. As a result, these fuel cells could significantly lower the cost of CCS, thereby bringing this breakthrough technology closer to widespread use.

Carbonate fuel cell technology could make CCS more affordable for power plants, which according to the U.S. Environmental Protection Agency are the single largest source of GHG emissions. In 2016, FuelCell Energy and ExxonMobil signed a joint agreement that will allow scientists from both companies to work collaboratively and further develop this emissions-saving technology.

Here’s how it could work:

1. The CO₂ released by power plants (millions of tonnes each year) makes these locations the perfect place to apply carbon capture.
2. The unique carbon-capture method being tested by ExxonMobil and FuelCell Energy could increase the electrical output by more than 25 percent at natural gas power plants, rather than decrease electrical output like the conventional carbon-capture processes.
3. The fuel cells are deployed at the power plant, where they capture up to 90 percent of the carbon in the exhaust stream. The fuel cells are themselves powered by hydrogen, which is derived from natural gas. The majority of the CO₂ will be removed from the fuel cell’s exhaust stream and collected for storage.
4. Because the fuel cells are modular, they can be more easily deployed at a wide range of locations.
5. Compressed CO₂ is safely piped more than 3,000 feet underground.
6. The compressed CO₂ is permanently stored underground.
How do fuel cells capture CO₂?

Energy innovators ExxonMobil and FuelCell Energy are collaborating on solving a big problem: how to capture CO₂ more efficiently on a large scale. The technology we’re working on uses fuel cells to separate CO₂ from the exhaust stream of a power plant, making the CO₂ easier to capture and pipe underground. While still early in development, this process could vastly reduce the amount of CO₂ released into the atmosphere. It also has the potential to dramatically reduce the costs of CCS, creating a pathway for its widespread use around the world.
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Could fuel cells be carbon-capture game changers?

Here are four reasons why:

1. Carbonate fuel cells can concentrate up to 90 percent of CO₂ emissions that come out of power plants – concentrated emissions can be more easily captured and stored deep underground.

2. Carbon capture using fuel cells generates power, which is critical to lowering the cost of carbon capture.

3. When carbonate fuel cells take CO₂ from the power plant, where they capture up to 90 percent of the carbon in the exhaust stream. The fuel cells are themselves powered by hydrogen, which is derived from natural gas. The majority of the CO₂ will be removed from the fuel cells exhaust streams and collected for storage.

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4. CLEANER AIR

Generates Power

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Customizable

Fuel cells are modular solutions, allowing for gradual investment decisions that help utilities meet carbon-capture targets over time.
Chemicals process breakthrough

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How does this breakthrough work?

Reverse osmosis has the potential to dramatically reduce the amount of energy required in plastics manufacturing. The technology employs a molecular-level filter – the molecules needed to produce plastics pass through; the others are recycled back into the process. This separation of molecules is a critical step in the production of plastics, but one that currently requires a lot of thermal energy. Because reverse osmosis works at room temperature, it may one day replace existing separation technology with a much less energy-intensive option.

Advanced products

ExxonMobil develops and produces a range of advanced products that reduce GHG emissions and improve sustainability. These include resilient, lightweight automotive plastics that reduce overall vehicle weight and advanced tire technologies that help maintain optimal tire pressure – both of which make vehicles more fuel-efficient.

ExxonMobil also produces lightweight packaging materials for everything from food to electronics. Lighter packaging means less transportation-related energy use and GHGs. Plastic packaging also helps extend the shelf life of fresh food by days or even weeks, improving safety and reducing food waste.

Our high-performance lubricants – used not just in cars and trucks, but in more than 40,000 wind turbines worldwide – improve sustainability because they need replacing less frequently, reducing the volume of used oil that needs to be disposed of or recycled.

A 10% reduction in vehicle weight can improve fuel economy by as much as 7%.
How does reverse osmosis work?
Organic solvent reverse osmosis is a manufacturing process that could replace energy-intensive technology at chemical plants.

HERE’S HOW IT WORKS:

1. By applying pressure at room temperature, hydrocarbon mixtures are pushed through a molecular filter.
2. This separates paraxylene — a chemical building block for polyester and certain plastics — from a mixture of other raw hydrocarbons that can be recycled back into the process.
3. This mixture can then be fed into conventional processes for finishing into plastics for products like electronics and auto parts.

If we used reverse osmosis to help make certain plastics, it could:

- Cut energy costs by $2 billion annually
- Reduce industry’s annual global carbon emissions by 45 million tonnes
- Even more responsibly meet demand for plastics
- Lower manufacturing costs can help keep products affordable for consumers
- Same carbon footprint as 5 million U.S. homes
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How is ExxonMobil fueling future energy discoveries?

Every day, ExxonMobil works with academic institutions around the world to research and develop new solutions to the world’s energy challenges. Our work includes everything from researching advances in materials science and carbon storage to understanding wind and solar energy. These collaborative relationships with colleges and universities fuel new discoveries and empower advanced energy research both in focused, short-term projects and multiyear programs.
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University research collaborations

- Beijing University of Chemical Technology
- Carnegie Mellon University
- Case Western Reserve University
- Changchun Institute of Applied Chemistry
- City College of New York
- College of William and Mary
- Colorado School of Mines
- Cornell University
- Delft University of Technology
- Drexel University
- Duke University
- Delft University of Technology
- Florida State University
- George Mason University
- Georgia Institute of Technology
- Heriot-Watt University
- Imperial College London
- Jacobs University Bremen
- Jiaotong University
- Joseph Fourier University
- Louisiana State University
- Massachusetts Institute of Technology
- Michigan State University
- Montana State University
- Moscow State University
- Nanyang Technological University
- New York University Abu Dhabi
- Newcastle University
- North Carolina State University
- Norwegian University of Science and Technology
- Pohang University of Science and Technology
- Princeton University
- Purdue University
- Qatar University
- Rice University
- Scripps University
- South China University of Technology
- Stanford University
- Texas A&M University
- Tianjin University
- Tulane University
- University of Alberta
- University of Bristol
- University of British Columbia
- University of Calgary
- University of California, Berkeley
- University of California, Irvine
- University of California, San Diego
- University of California, Santa Barbara
- University of Cambridge
- University of Delaware
- University of Florida
- University of Hawaii
- University of Houston
- University of Illinois at Urbana-Champaign
- University of Leeds
- University of Massachusetts Amherst
- University of Minnesota
- University of Michigan
- University of Minnesota
- University of Notre Dame
- University of Oklahoma
- University of Pennsylvania
- University of Pittsburgh
- University of Toronto
- University of Texas at Austin
- University of Texas at El Paso
- University of Texas at Austin
- Virginia Polytechnic Institute and State University
- Vrije Universiteit Brussel
- Western Michigan University

As of 2017
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California Institute of Technology
Cambridge Mellon University
Carolina Western Reserve University
Changshu Institute of Applied Chemistry
City College of New York
College of William and Mary
Colorado School of Mines
Carnegie Mellon University
Delft University of Technology
Diel University
Duke University
Dutch Polymer Institute
Florida State University
George Mason University
Georgia Institute of Technology
Heriot-Watt University
Imperial College London
Jacobs University Bremen
Jiangsu University
Joseph Fourier University
Louisiana State University
Massachusetts Institute of Technology
Michigan State University
Minnesota State University
Moscow State University
Norwegian University of Science and Technology
North Carolina State University
Norwegian University of Science and Technology
Pohang University of Science and Technology
Princeton University
Purdue University
Queen’s University
Rice University
Sichuan University
South China Institute of Technology
Stanford University
Texas A&M University
Texas A&M University at Galveston
Texas A&M University
University College Dublin
University of Alberta
University of Bristol
University of British Columbia
University of Cape Town
University of California, Berkeley
University of California, Irvine
University of California, Riverside
University of California, San Diego
University of California, Santa Barbara
University of Cambridge
University of Delaware
University of Florida
University of Hawaii
University of Illinois at Urbana-Champaign
University of Leeds
University of Massachusetts
Athenes
University of Milan
University of Michigan
University of Michigan
University of Minnesota
University of Missouri
University of North Texas
University of Notre Dame
University of Oklahoma
University of Pennsylvania
University of Reading
University of Southern Mississippi
University of Sheffield
University of Strasbourg
University of Texas at Austin
University of Texas at El Paso
University of Utah
University of Virginia
University of Washington
University of Wisconsin
University of Wyoming
Utah State University
Virginia Polytechnic Institute and State University
Vrije Universiteit Brussel
Western Michigan University
Xiamen University
Aalto University
As of 2017
University research collaborations

In addition to in-house research, ExxonMobil works with approximately 80 universities globally to explore next-generation energy technologies. We are a member of the MIT Energy Initiative, which supports advanced energy research. We have a collaboration with Princeton University in fields including solar and battery technology, and an agreement with the University of Texas to study carbon storage and other technologies.

ExxonMobil was a founding member of the Global Climate and Energy Project at Stanford University, which seeks to develop game-changing breakthroughs that could lead to lower GHG emissions and a less carbon-intensive global energy system.

Other collaborations range from understanding the impacts of black carbon and aerosols (University of California, Riverside) to the conversion of cellulosic sugars to fuels (University of Wisconsin).

$145M

ExxonMobil has committed $145 million to fund breakthrough energy research at MIT, Princeton, the University of Texas and Stanford.