Low Carbon Solutions

Accelerating the world's paths to net zero and building a compelling new business

Emission-reduction markets have the potential to grow rapidly and reach massive size in a world progressing toward net zero. This provides significant opportunities for our Low Carbon Solutions business, which represents an important and attractive element of the company's plans to profitably grow for many years to come.

Our organization is clear-eyed on the challenges. We also understand the unique and important contributions we can make, and we are embracing the new opportunities.

Our customers, many governments, and others recognize our combination of experience, skills, and capabilities that can meaningfully help reduce the emissions of others.

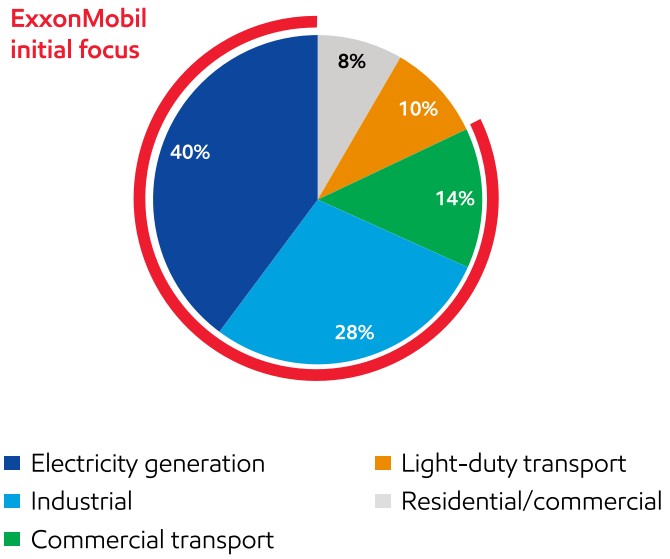
Our strategy is geared toward ensuring strong returns and value growth as the energy transition progresses.

Today the world generates about 34 billion metric tons of energy-related CO_2 emissions per year. Industrial activity, power generation, and commercial transportation together account for 80% of all energy-related CO_2 emissions.[1] And while electric vehicles are important and get a lot of headlines, it's worth noting that these sectors account for about eight times the carbon emissions of passenger vehicles each year. We're focused on these hard-to-decarbonize sectors. They must be tackled for society to reach net zero.

And that's where our capabilities come in.

Energy-related CO_2 emissions by sector, 2021[1]

34 billion metric tons

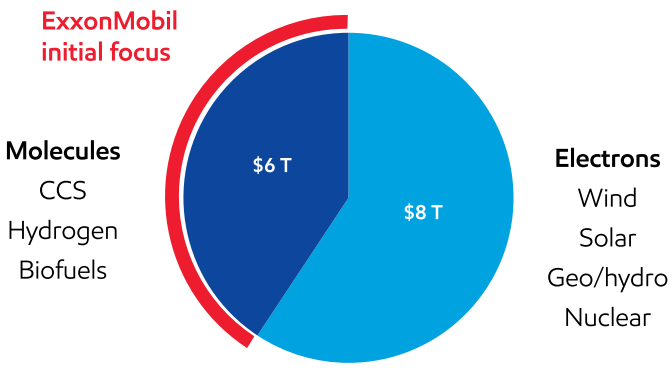


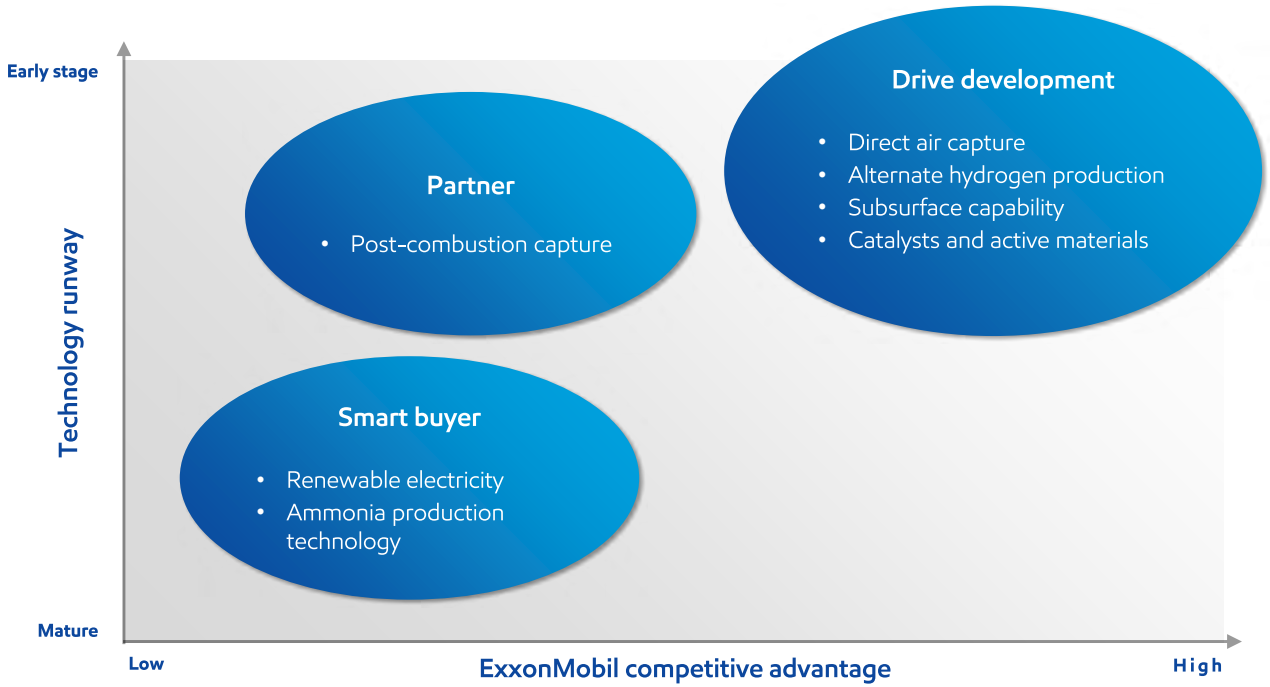
Our company manages **molecules**. It's what we have done for decades, and it's where we're focused today. This work involves technologies for capturing, transporting, and storing molecules; producing hydrogen from other molecules; and sourcing and co-processing lower-carbon-intensity molecules – all of which require the same competitive advantages we've built in our traditional businesses. These markets could exceed $6 trillion globally by 2050.[3]

Government policy plays a key role in building these new markets, especially in the near term.

Most of our activity is focused in the United States, which is being accelerated by incentives in the U.S. Inflation Reduction Act (IRA). We support legislation like the IRA, which provides incentives for companies to be part of the solution. European policy is currently more prescriptive on how emissions must be managed, which limits solutions for the hard-to-decarbonize sectors. At this early stage, supportive policy remains critical to enable emissions reductions, advance technology, and drive scale to improve costs. Ultimately, given the size of the challenge and the costs entailed, a market for emissions reduction will be required to achieve society's net-zero ambition.

Potential size of low-carbon markets, 2050[2]





Technology is already playing a critical role, and it's where we can add real value.

To expand that advantage further, we're tailoring our approach in any given abatement technology as a function of the following:

- First, we're applying resources and driving development in those areas where we think there is an ample technology runway and where we can add value. These are the areas where we're working on the development of new and potentially breakthrough technologies. Examples include direct air capture, alternate methods of hydrogen production, and application of our deep capabilities in the subsurface for carbon storage. And while we're a leader in the technology development in these programs, we're continuing to work with other companies, governments, or academic institutions that bring unique value to the table.

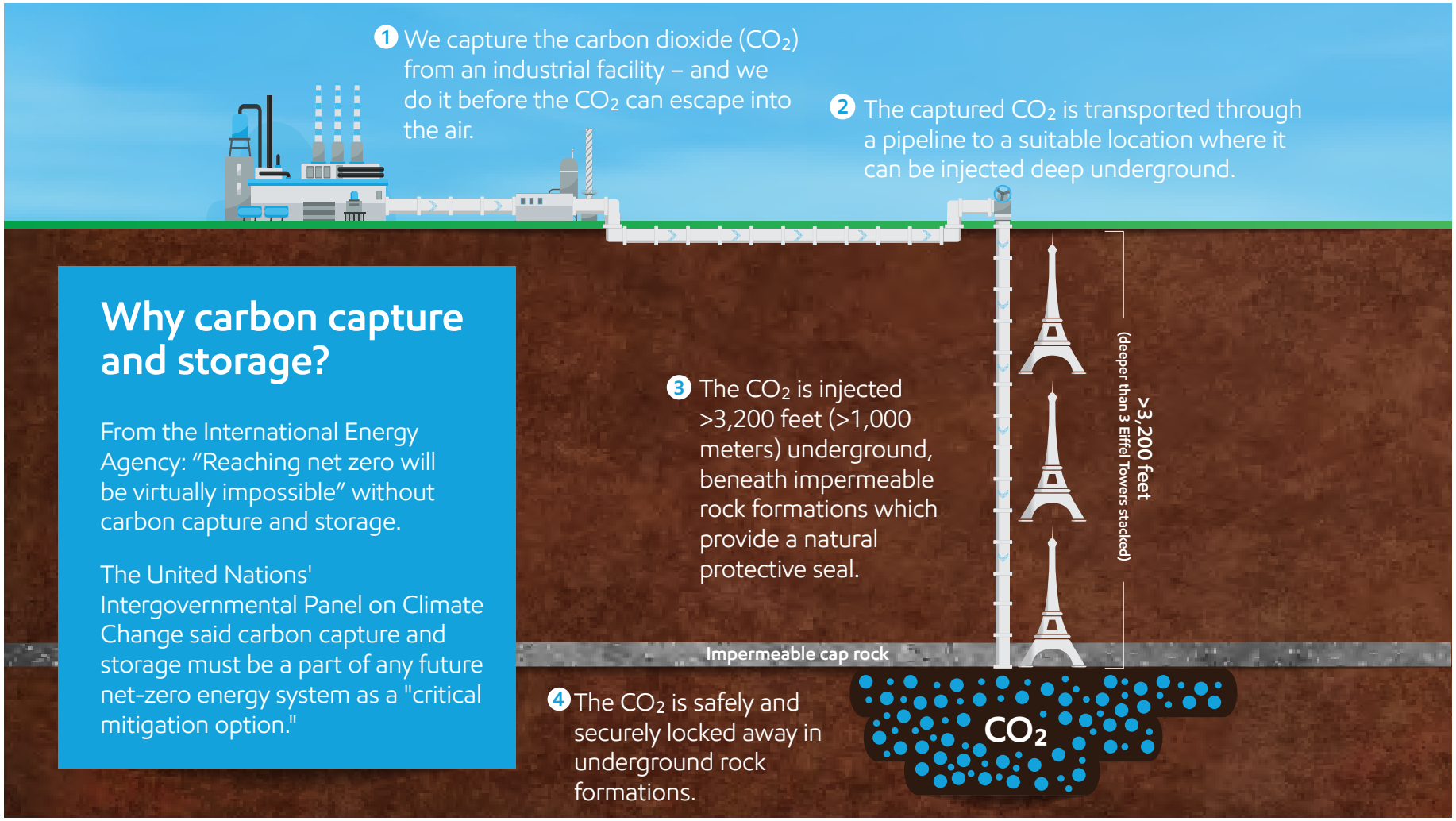
- Second are areas where there is significant runway but where we have less existing advantage. In those areas, we're looking to partner. An example of this is the Mitsubishi Heavy Industries (MHI) post-combustion capture partnership. We're integrating existing MHI technology into our "one-stop-shop" carbon capture, transportation, and storage offering, and we are working on joint technical development with MHI to further advance the technology with the goal of lowering the cost of abatement.

- Third, where technology is mature, and we do not bring a unique competitive advantage, we're looking to purchase or license from established vendors as a smart buyer. Two good examples here are ammonia production and renewable power, which are both well-established technologies with experienced developers.

As we strive to play a leading role in the energy transition, we're pursuing more than $20 billion in lower-emission investments from 2022 through 2027, in addition to the approximately $5 billion Denbury acquisition. About 50% of our lower-emission investments are targeted at reducing emissions from operated assets, with the balance going toward reducing the emissions of other companies.

Carbon capture and storage

ExxonMobil is a global leader in carbon capture and storage



What it is

Carbon capture, transportation, and storage is just what the term implies. Once CO_2 is captured at factories or power plants, we transport and inject it into geologic formations thousands of feet below the earth's surface for safe and secure storage. The injected CO_2 is held in place by thick, impermeable seal rocks.

Carbon capture and storage, on its own or combined with hydrogen production, is one of the few proven technologies that could enable significant CO_2 emission reductions from high-emitting and hard-to-decarbonize sectors. These include power generation, refining, steel, cement, and petrochemicals manufacturing. According to the Center for Climate and Energy Solutions, carbon capture and storage can capture more than 90% of CO_2 emissions from power plants and industrial facilities.[4]

What respected third parties are saying about carbon capture and storage

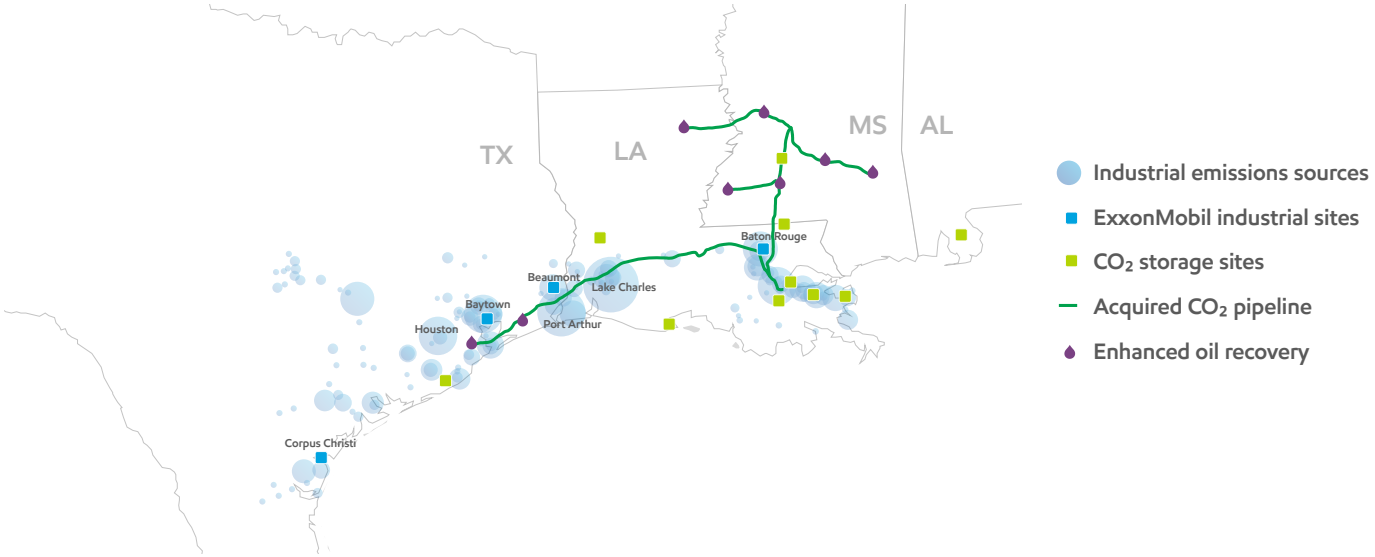
Both the International Energy Agency (IEA) and the United Nations Intergovernmental Panel on Climate Change (IPCC) see carbon capture and storage as key to reaching global emissions goals.

The IEA NZE report concludes that more than 7.6 billion metric tons per year of CO_2 will need to be captured and stored by 2050 to reach a net-zero future. By comparison, the world's current capture capacity is about 40 million metric tons of CO_2 per year.[5] The agency has also said "reaching net zero will be virtually impossible" without carbon capture and storage.[6]

The IPCC estimates that the cost of achieving a 2°C outcome would more than double without carbon capture and storage.[7]

We identify opportunities with concentrated streams of CO_2 near sites with safe and secure storage space, and where we can use existing infrastructure to gain scale to offer economical solutions to customers.

Denbury acquisition creates strong U.S. Gulf Coast CO_2 infrastructure position



Note: All information shown is approximate (e.g., storage / pipeline location) and has potential to change as projects are developed and implemented.

Leading now

With more than 30 years of experience in carbon capture, we lead the industry in the successful deployment of this technology at scale. We are continuing to develop and expand our capacity for storing CO_2 on a long-term basis.

On the U.S. Gulf Coast, we're building carbon capture and storage infrastructure that will allow industrial customers to work with us to significantly reduce their emissions. We expect the first of our Gulf Coast projects to be operational as soon as 2026.

Because carbon capture and storage projects require geologic space, we continue to add suitable acreage both onshore and offshore, for this use. Building on our long record of successful collaborations with host governments around the world, we are also negotiating to gain access to nationally owned acreage that holds potential for CO_2 storage. We also continue working with the local jurisdictions on the appropriate permitting to sequester CO_2, which will be essential to the success of these projects.

Another vital element of establishing a successful business is building a customer base. And in this area, we're making great progress with customers that include a major fertilizer company, an industrial gas producer, and a leading steel manufacturer:

- **CF Industries**, a leading global manufacturer of hydrogen and nitrogen products, signed the largest of its kind commercial agreement with us to capture and permanently store up to 2 million metric tons of CO_2 emissions annually from its manufacturing complex in Louisiana. The project supports Louisiana's objective of net-zero CO_2 emissions by 2050.
- **Linde**, one of the world's leading industrial gases and engineering companies, entered into a long-term commercial agreement with us in which ExxonMobil will capture, transport, and permanently store up to 2.2 million metric tons of CO_2 each year from Linde's new clean hydrogen production facility in Beaumont, Texas.
- **Nucor Corp.**, North America's largest steel and steel products producer, entered into a long-term commercial agreement with us, in which ExxonMobil will capture, transport, and store up to 800,000 metric tons of CO_2 per year from Nucor's manufacturing site in Convent, Louisiana.

Working to grow our leadership in carbon capture and storage

CF Industries		Linde		Nucor		Capture
2	+	**2.2**	+	**0.8**	=	**5**
million metric tons of CO_2 per year		million metric tons of CO_2 per year		million metric tons of CO_2 per year		million metric tons of CO_2 per year

equivalent to replacing nearly 2-million gasoline-powered cars with electric vehicles[8]

Our acquisition of Denbury Inc. supports these major projects and opens opportunities for many others along the U.S. Gulf Coast and in other locations.

The acquisition provides ExxonMobil with the largest owned and operated network of CO_2 pipelines in the United States. Combining Denbury's assets and experience with our capabilities significantly expands our ability to profitably help customers reduce their emissions.

Of Denbury's 1,300 miles of CO_2 pipeline, roughly 70% is in the Gulf Coast states of Louisiana, Texas, and Mississippi — one of the largest U.S. markets for CO_2 reduction and home to some of ExxonMobil's largest integrated refining and chemical sites. Denbury also brings strategically located CO_2 storage sites in this region.

We believe these synergies will drive strong growth and returns for our shareholders. A cost-efficient transportation and storage system accelerates carbon capture and storage deployment for both ExxonMobil and our third-party customers. It supports multiple low-carbon businesses – including carbon capture and storage, hydrogen, ammonia, and biofuels.

Ultimately, we continue to see potential, working with others in the industry, to create a carbon capture and storage business with the capacity to reduce emissions across the Gulf Coast by more than 100 million metric tons per year.[9] This transaction is part of our efforts to do that at a lower cost and faster pace.

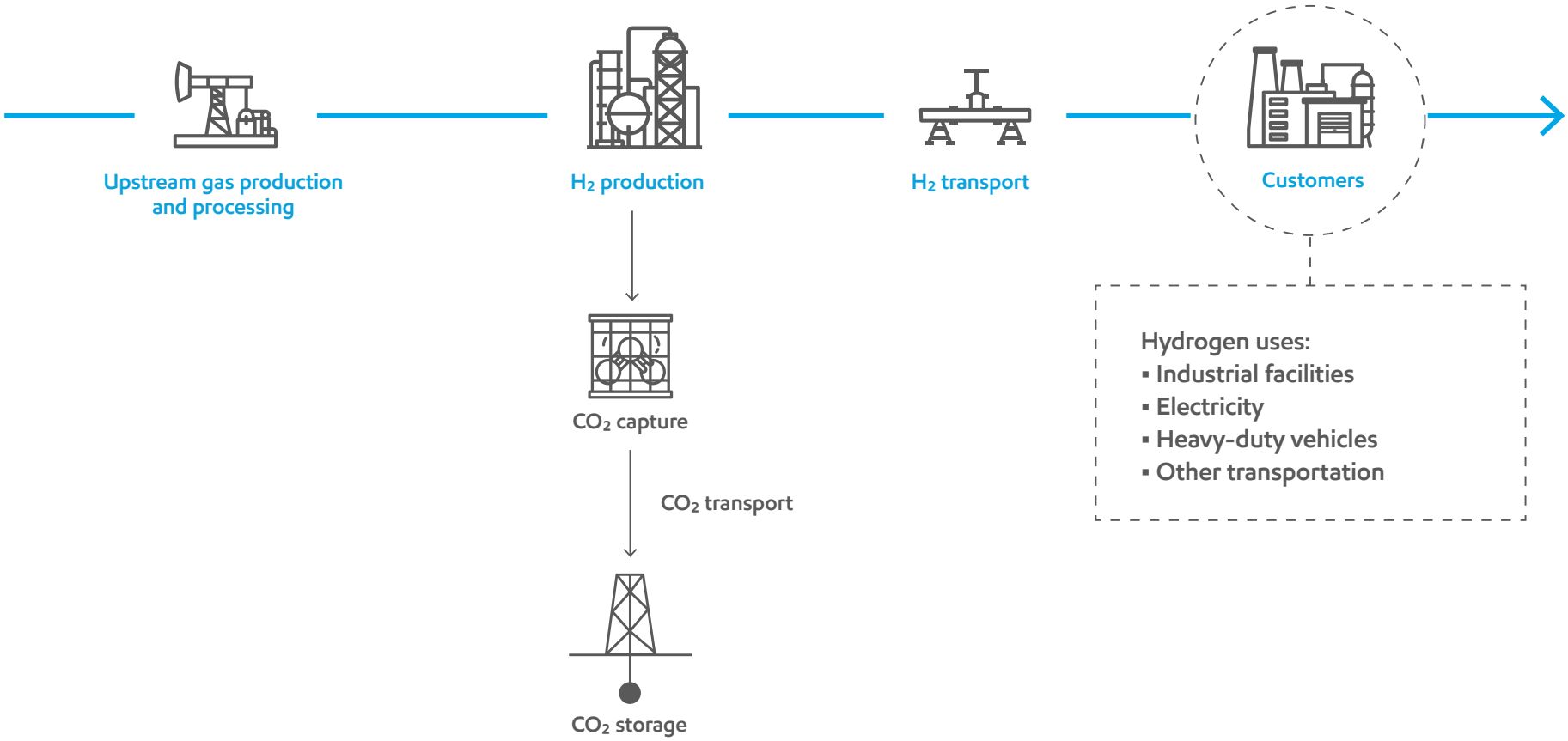
What's next

- **Improving capture:** We continue to research processes, compounds, and materials to capture carbon more efficiently. These innovations include a new metal organic framework[10] that is highly selective to CO_2, as well as advanced amines that provide enhanced efficiency and stability.[11]
- **Developing materials:** We are working closely with suppliers and logistics partners to develop new designs for offshore transport, while we partner with a wide range of experts on materials integrity for pipeline transport and storage of CO_2.
- **Studying storage:** We are working with leading universities and other research organizations to improve modeling of geologic storage,[12] including seal characterization for containment assessment, as well as optimal long-term monitoring of stored CO_2. Our research and experimental efforts are advancing knowledge in areas such as monitoring requirements and effective storage capacity.

Hydrogen

What it is

Hydrogen is a zero-carbon energy source that can generate the high temperatures needed to produce steel, cement, and refining and chemical products without carbon dioxide emissions. This means it could serve as an affordable and reliable source of energy for hard-to-decarbonize industrial processes.



Leading now

Just as we have a long history with carbon capture and storage, we have deep and broad experience with hydrogen as well. We use hydrogen in just about every one of our refining and chemical plants, and we're looking to expand that.

Baytown future hydrogen plant

In Baytown, Texas, we are developing the world's largest low-carbon hydrogen production facility. It's being designed to produce 1 billion standard cubic feet of hydrogen per day, which is equivalent to the energy needed to power 1.5 million homes.[13] This single project would represent nearly 10% of the Biden administration's goal as reflected in the U.S. National Clean Hydrogen Strategy and Roadmap.[14] We expect to capture more than 98% of the CO_2, or about 7 million metric tons per year, associated with producing this hydrogen. The new plant could supply Gulf Coast industrial customers, as well as our own facilities in the Baytown area, with clean-burning hydrogen fuel for process operations. In addition, tapping into our certified lower-emission natural gas from the Permian Basin should further lower carbon intensity that will be very difficult for others to match. Front-end engineering is underway. Startup is expected as soon as 2028.

What's next

- **Studying technology advances and transport**
  We are participating in cross-industry initiatives to identify the technology advancements and government policies required to deploy low-carbon hydrogen at scale. For example, natural gas transmission infrastructure has the potential to be used for hydrogen transport. Our membership in the U.S. HyBlend consortium will help address the technical barriers of blending hydrogen into natural gas pipeline systems.[15] In addition to working with industry organizations to develop hydrogen transportation standards, we're working with the U.S. Department of Energy to advance understanding of the challenges and opportunities involved.

- **Energy initiative**
  We are working with the MIT Energy Initiative[16] to develop a new carbon life-cycle tool that measures the end-to-end carbon emissions from different technologies, including blue hydrogen. This tool can help inform policymakers as they consider legislation to incentivize investments in technologies that are needed to lower societal emissions in an affordable and practical way.

Lower-emission fuels

What they are

These fuels generate less emissions over their life cycle than the traditional fuels they replace. They include biofuels made from renewable sources like plants and waste biomass and synthetics made from hydrogen and captured carbon dioxide. Lower-emission fuels have the high energy density required to move heavy trucks. Renewable diesel can reduce carbon emissions by up to 70% compared to conventional diesel.[17] Demand for these fuels is expected to grow rapidly, driven by the aviation, marine, and heavy-duty trucking industries. Our Global Outlook projects almost 9 million oil-equivalent barrels per day of these fuels by 2050, more than four times 2021 levels.

Our Product Solutions business is focused on growing lower-emission fuels by leveraging current technology and infrastructure, while our Low Carbon Solutions business is focused on innovation in the next generation of low-emission fuels which are supported by our other low-carbon businesses like carbon capture and storage.

We're exploring opportunities to combine biomass-based fuel production with carbon capture and storage, enabling very low- or negative-carbon intensity fuel production. We're also looking at how we can efficiently transform natural gas into methanol-based fuels. Our existing capability to convert methanol to multiple end-use fuels, such as marine and jet fuel, could enable a range of low- to zero-emissions fuels. Low-emission fuels can utilize existing distribution infrastructure, further enabling their cost-effective deployment.

Leading now

- **Strathcona, Canada**: We are ramping up renewable fuel production at our Imperial Oil refinery near Edmonton, where we're building the technology and infrastructure to provide renewable diesel to several industries in western Canada. When completed in 2025, the facility is expected to be the largest of its kind in Canada, with capacity of 20,000 barrels a day.
- **Singapore**: We leveraged our integrated refining and petrochemical complex in Singapore and our logistics network in 2022 to deliver the first cargo of certified sustainable aviation fuel (SAF) to Changi Airport as part of a one-year pilot.[18]

What's next

- **Maritime goals**: ExxonMobil supports the International Maritime Organization's (IMO) ambition to reduce total annual GHG emissions from international shipping to reach net-zero by or around 2050. We are working to help our customers determine their best route toward meeting the IMO's GHG emission-reduction goals. As part of this initiative, we are supplying ExxonMobil bio marine fuel oil blends at our Singapore and Amsterdam-Rotterdam-Antwerp bunkering hubs.
- **Testing with Toyota**: ExxonMobil is exploring innovative fuel blends with the potential to reduce emissions from road transportation by up to 75% versus conventional fuels available today. In a test we conducted with Toyota Motor Corp. in 2023, our fuels under development proved compatible with today's vehicles and existing infrastructure. Fuels that work with current networks will reduce or eliminate the need to build new pipelines and tanks, accelerating and lowering the cost of deployment.
- **Co-processing**: We are conducting co-processing trials in our facilities using proprietary technology to produce lower-emission fuels, including sustainable aviation fuels. We are evaluating how to deploy our capacity to co-process 100,000 barrels per day of lower-emission fuels to markets where supportive policy exists. The ability to process biofeed and conventional feedstock together through an existing fluid catalytic cracker or hydrotreater will allow for faster, lower-cost delivery of these fuels to customers compared to construction of new facilities requiring large capital investments.
- **Fats to fuel**: We are evaluating opportunities to lower life-cycle emissions through conversion of bio-based feedstocks for diesel production. With the processes ExxonMobil has developed and our proprietary dewaxing catalyst, we can convert waste fats or vegetable oils into renewable fuels with less byproduct formation and hydrogen consumption than other methods. With an additional step, and provided we can obtain ample feedstocks, we could use this same process to make sustainable aviation fuels.
- **New jet fuel technology**: We recently announced a new technology that can produce jet fuel using renewable methanol as the feedstock.[19] This methanol has a lower carbon intensity and can be made through either gasification of biofeeds, such as wood waste, or captured CO_2 and H_2 made by electrolysis of water using renewable electricity. The lower-emission methanol can be converted into sustainable aviation fuel using our innovative technology. We expect this process will provide a higher yield of jet fuel than other techniques for the same feedstock, with the potential to be used to make other fuels or chemicals.

Lithium

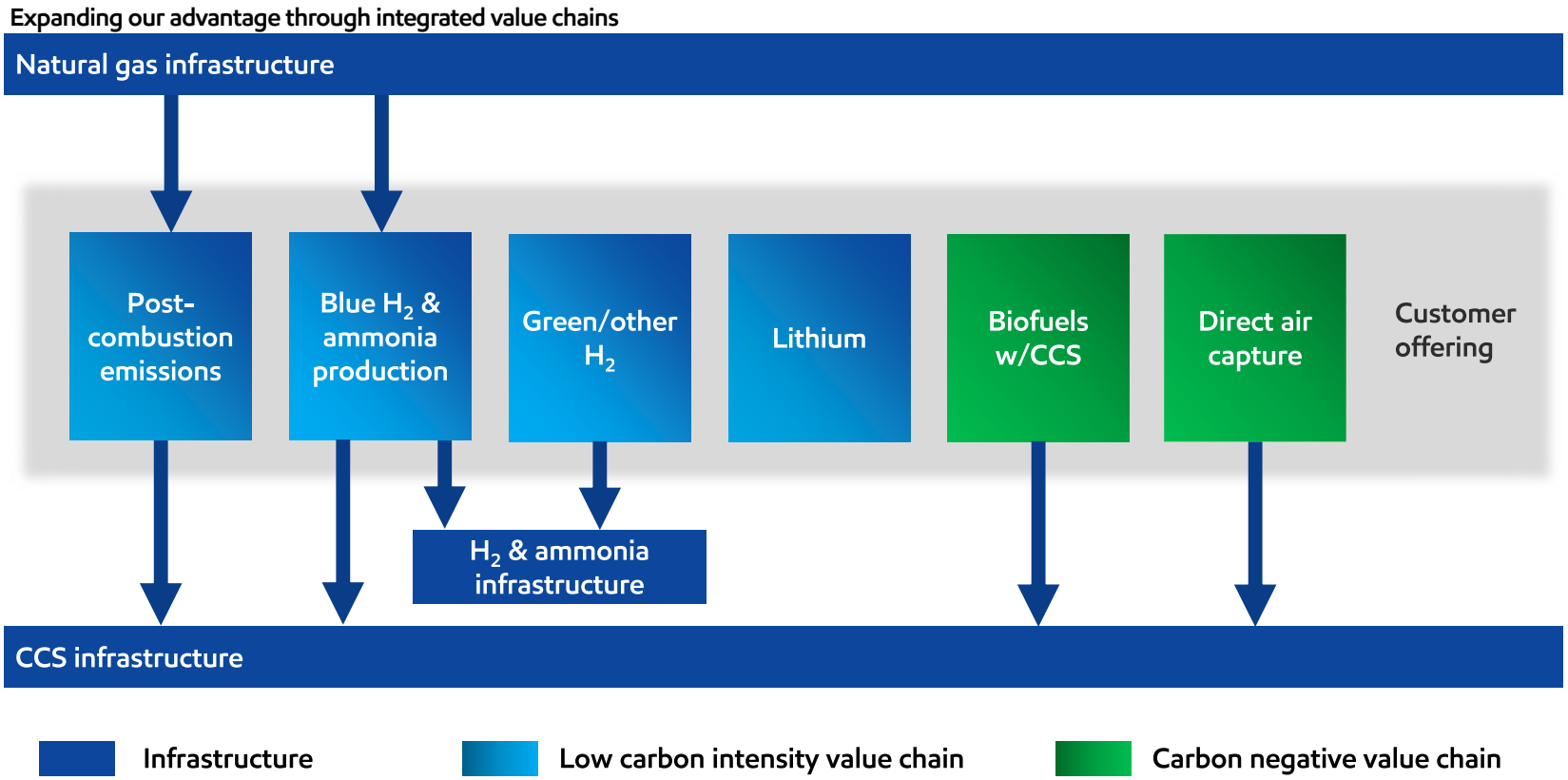
What it is

Lithium is used for the batteries in electric vehicles and portable electronic devices. Batteries account for 80% of global lithium use. Global consumption of lithium was 134,000 tons in 2022, up 41% from 2021, according to the U.S. Geological Survey.[20] The International Energy Agency expects demand to keep rising, potentially reaching over 1 million tons by 2040.[21]

Leading now

In November, we announced plans to produce lithium carbonate for use in EV battery manufacturing by employing direct lithium extraction (DLE) technology in southern Arkansas. By separating the lithium from deep brine reservoirs using available technologies, we're working to produce this critical mineral more efficiently and with fewer environmental impacts than traditional hard rock mining. Our existing skills in subsurface exploration, drilling, refining, and chemicals will allow us to bring meaningful scale to this technology and provide auto battery manufacturers with a more reliable, lower-carbon lithium supply option.[22]

Other solutions



Carbon capture and storage, hydrogen, lower-emission fuels, and lithium are far from the only emission-reduction opportunities in the world. We are always looking for opportunities that fit our strengths and leverage our current capabilities and businesses.

For example, many of our natural gas and LNG customers have significant post-combustion emissions that they'd like to abate. We offer a "one-stop shop" for CO_2 capture, transportation, and storage that will enable these customers to reduce their emissions.

We're working to accelerate the world's paths to net zero. We're building on our technology, scale, project execution, and integration advantages to establish a compelling new business. We're leading now with real-world projects moving into execution, and a pipeline of future opportunities. We believe this new business complements our existing businesses and will underpin the corporation's future growth and returns for decades to come.

Footnotes

1. ExxonMobil 2023 Global Outlook.
2. Total addressable market based on ExxonMobil analysis of the IPCC's Sixth Assessment Report Scenarios Database hosted by IIASA for carbon capture and storage, wind, solar, hydrogen, nuclear, biofuels, geothermal, and hydropower. Secondary energy demand and prices in 2050 in the Likely Below 2°C scenarios (Category C3) were used, where available, to calculate an estimate of potential market revenue. Carbon capture and storage estimate includes both CCS and direct air capture and used price of carbon for pricing estimate. Biofuels estimate used liquids pricing for pricing estimate. 2020 dollars.
3. Ibid.
4. Center for Climate and Energy Solutions, https://www.c2es.org/content/carbon-capture/.
5. International Energy Agency (2021), Net Zero by 2050, IEA, Paris, https://www.iea.org/reports/net-zero-by-2050.
6. IEA (2020), Energy Technology Perspectives 2020: Special Report on Carbon Capture Utilisation and Storage. https://www.iea.org/reports/ccus-in-clean-energy-transitions.
7. O. Edenhofer et al., Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change: https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_full.pdf.
8. ExxonMobil analysis based on assumptions for U.S. in 2022, including average distance traveled, fuel efficiency, average power grid carbon intensity, electric vehicle charging efficiency, and other factors. Gas-powered cars include light-duty vehicles (cars, light trucks and SUVs).
9. Market potential for emission reduction opportunity based on ExxonMobil analysis of CO_2 pipeline routes, current and potential capacity, potential emitters in the U.S. Gulf Coast market, and potential infrastructure upgrades. Subject to additional investment by ExxonMobil, customer commitments, supportive policy, and permitting for carbon capture and storage projects.
10. E. J. Kim; R. L. Siegelman; H. Z. Jiang; A. C. Forse; J.-H. Lee; J. D. Martell; P. J. Milner; J. M. Falkowski; J. B. Neaton; J. A. Reimer. Cooperative carbon capture and steam regeneration with tetraamine-appended metal–organic frameworks. Science 2020, 369 (6502), 392-396.
11. P. Kortunov, M. Siskin, L. Baugh, D. Calabro "In Situ Nuclear Magnetic Resonance Mechanistic Studies of Carbon Dioxide Reactions with Liquid Amines in Aqueous Systems: New Insights on Carbon Capture Reaction Pathways" Energy Fuels, 29, 9, 5919–5939 (2015).
12. G. Wen, M. Tang, S. M. Benson, Towards a predictor for CO_2 plume migration using deep neural networks, Int. J. Greenhouse Gas Control, 105, 103223, 2021.
13. ExxonMobil analysis leveraging the average annual electricity consumption for a U.S. residential utility customer in 2021 per https://www.eia.gov/tools/faqs/faq.php?id=97 and assumed efficiency of a natural gas combined cycle plant on a lower heating value basis.
14. U.S. National Clean Hydrogen Strategy and Roadmap: https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/us-national-clean-hydrogen-strategy-roadmap.pdf.
15. HyBlend: Pipeline CRADA Materials R&D, https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/review22/in035_san_marchi_2022_o-pdf.pdf.
16. E. Gencer, S. Torkamani, I. Miller, T. Wu, F. O'Sullivan, Sustainable energy system analysis modeling environment: analyzing life-cycle emissions of the energy transition, Applied Energy 277 (2020) 115550.
17. Based on ExxonMobil analysis using Argonne National Labs' GREET2022 model and published fuel carbon intensity from California LCFS regulations. Argonne National Laboratory GREET model: https://greet.anl.gov/, California Air Resources Board Low Carbon Fuel Standard Regulation: https://ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard/lcfs-regulation.
18. EM Press Release (Jul 2022): https://www.exxonmobil.com/en/aviation/knowledge-library/resources/em-marks-first-certified-blended-sustainable-aviation-fuel-delivery-to-singapore-changi-airport.
19. EM Press Release (Oct 2023): https://www.exxonmobilchemical.com/en/resources/library/library-detail/109708/exxonmobil_aramco_neom_methanol_to_gasoline_technology_en.
20. https://pubs.usgs.gov/periodicals/mcs2023/mcs2023-lithium.pdf.
21. https://www.iea.org/data-and-statistics/data-tools/critical-minerals-data-explorer.
22. Expected smaller footprint of lithium mining and expected lower carbon and water impacts: EM analysis of external sources and third party life-cycle analyses. 1) Vulcan Energy, 2022 https://v-er.eu/wp-content/uploads/2022/04/Apr-Corp-Preso.pdf, Minviro publication. Grant, A., Deak, D., & Pell, R. (2020). 2) The CO_2 Impact of the 2020s Battery Quality Lithium Hydroxide Supply Chain-Jade Cove Partners. https://www.jadecove.com/research/liohco2impact. Kelly, J. C., Wang, M., Dai, Q., & Winjobi, O. (2021). 3) Energy, greenhouse gas, and water life cycle analysis of lithium carbonate and lithium hydroxide monohydrate from brine and ore resources and their use in lithium ion battery cathodes and lithium ion batteries. Resources, Conservation and Recycling, 174, 105762.