

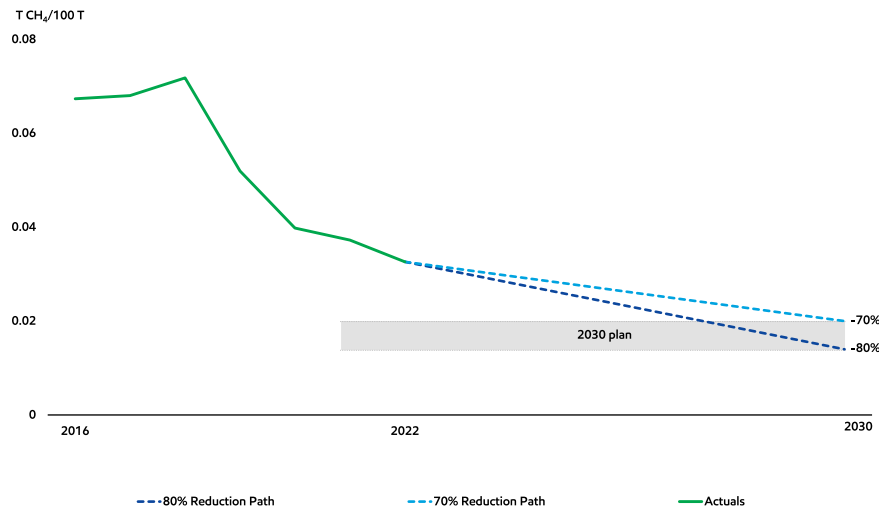
# Methane

## Driving reductions in methane emissions

Highlighting our progress

What we've done	What we're doing
<ul style="list-style-type: none"> <li>▪ Cut operated methane emissions intensity in half since 2016</li> </ul>	<ul style="list-style-type: none"> <li>▪ On plan to reduce methane intensity versus 2016 across all operated assets 70%-80% by 2030<sup>1</sup></li> </ul>
<ul style="list-style-type: none"> <li>▪ Eliminated routine flaring in Permian Basin operated assets</li> </ul>	<ul style="list-style-type: none"> <li>▪ On track to achieve zero routine flaring across all operated upstream assets by 2030, consistent with World Bank Zero Flaring Initiative<sup>2</sup></li> </ul>
<ul style="list-style-type: none"> <li>▪ Eliminated "high-bleed" pneumatic devices in our U.S. operated unconventional assets</li> </ul>	<ul style="list-style-type: none"> <li>▪ On track to eliminate natural gas-driven pneumatic devices by 2025 in our key U.S. unconventional operated assets</li> </ul>
<ul style="list-style-type: none"> <li>▪ In 2022 alone, we surveyed 2.3 million components with optical gas imaging cameras and 1.3 million components with aerial flyovers</li> </ul>	<ul style="list-style-type: none"> <li>▪ Expanding continuous monitoring program in the Permian to cover ~700 unconventional production sites by 2025</li> </ul>
<ul style="list-style-type: none"> <li>▪ Progressed collaborations including deciding to join the U.N. Oil and Gas Methane Partnership (OGMP) 2.0</li> </ul>	<ul style="list-style-type: none"> <li>▪ Partnering with Scepter to launch 2 monitoring satellites in 2025 with a plan to have 24 in place over the next three years</li> </ul>
<ul style="list-style-type: none"> <li>▪ Launched our Center for Operations and Methane Emissions Tracking (COMET) in 2022 to provide near-continuous real-time monitoring</li> </ul>	

## Reducing corporate-wide methane emissions intensity



## Methane: The other greenhouse gas

Methane is a deceptively simple molecule.

With just one carbon and four hydrogen atoms, it's the principal component in natural gas. Methane has the high energy density needed to make natural gas a reliable and flexible energy source that is already helping to meaningfully reduce carbon emissions around the world and will continue to be critical in achieving a lower-emission future. Our [Global Outlook](#) forecasts natural gas to make up more than 25% of the global energy mix in 2050.

Here are a few reasons why natural gas is such a great option:

- Choosing natural gas-fired electricity generation to replace older, inefficient coal plants can reduce greenhouse gas emissions by up to 60%, while producing fewer air pollutants.
- Natural gas resources are geographically and geologically diverse and abundant; natural gas is reliable and versatile for everything from power to transportation to home use.
- Natural gas is a reliable source for the required backup power generation when the wind isn't blowing enough to turn wind turbines and the sun isn't shining to fuel solar panels.

But, as with any form of energy, there are tradeoffs. For natural gas, in addition to CO<sub>2</sub>, it's the issue of fugitive methane – or put simply, methane that is leaked to the atmosphere, where it is a potent greenhouse gas. It exists for a short time when compared to CO<sub>2</sub>, but with a higher global warming potential. In fact, on a 100-year timespan, each kilogram of methane equals about 30 kilograms of CO<sub>2</sub>.<sup>3</sup>

That's why it's important for us to keep methane contained and managed in our operations – in our pipeline networks, in our storage tanks, and in our processing equipment.

Managing methane is good business. Fewer methane leaks also means more product to sell.

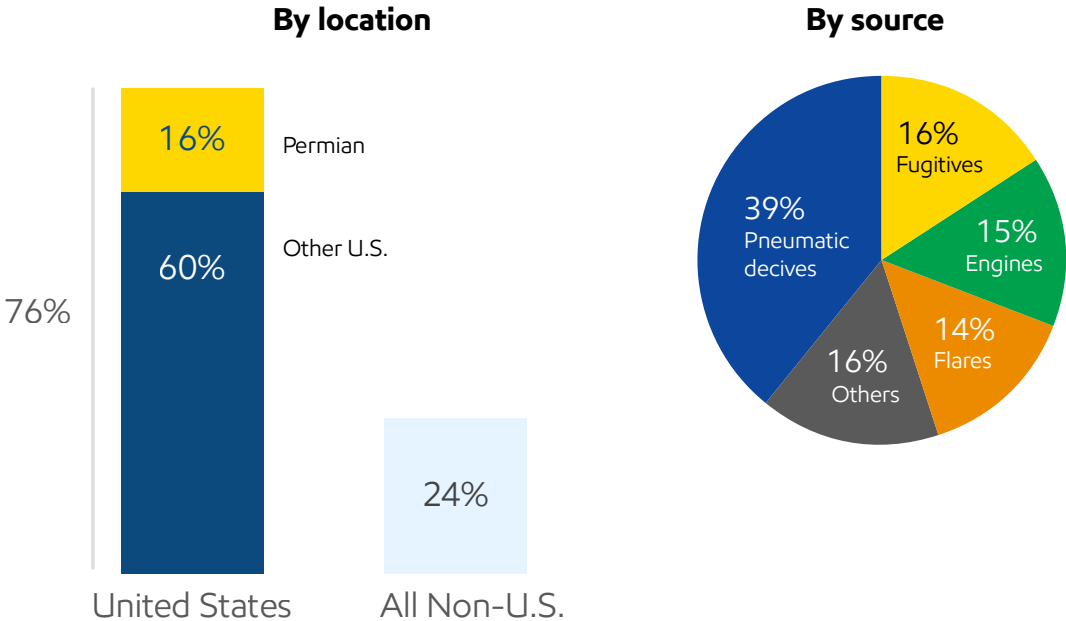
# Methane at ExxonMobil

Methane emissions in our industry come from four primary sources:

- **Flaring** is the burning of excess natural gas for safety or other reasons, resulting in CO<sub>2</sub> emissions.
- **Venting** is when pneumatic devices, storage tanks, dehydration units, and other components of our operations sometimes release excess methane from our equipment to the atmosphere to reduce pressure and help ensure personnel safety.
- **Fugitive emissions** that occur when we experience unintentional leaks from our equipment.
- **Combustion slip** is uncombusted methane left over in the exhaust of natural gas fired engines used to power operations.

As reported in our [data table](#), methane emissions at ExxonMobil were approximately 140,000 metric tons CH<sub>4</sub> in 2022, about 4% of our total Scope 1 emissions on an operated basis. The charts below illustrate where we have our biggest opportunities to tackle the methane challenge and provide greater transparency into the sources of methane emissions from our upstream operations, which comprise 96% of our methane emissions.

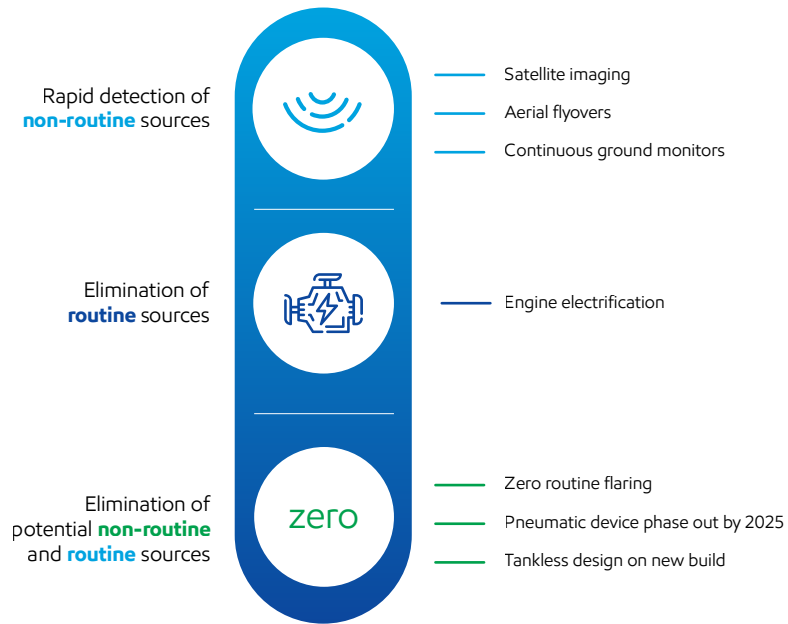
## ExxonMobil methane emissions<sup>4</sup>



### The methane challenge

Methane is odorless and colorless. When leaked, there are only a small number of methane molecules relative to the volume of surrounding air. A gust of wind can easily disperse those molecules, obscuring the source. Our assets are often in remote locations with extreme weather conditions, making detection a challenge.

Finding methane leaks in those environments, across vast acreage, is not simple. Methane emissions are not concentrated at certain points or at certain times in our operations. Leaks can be short in duration, low in volume, infrequent in occurrence, and therefore harder to identify.



### Aiming for zero

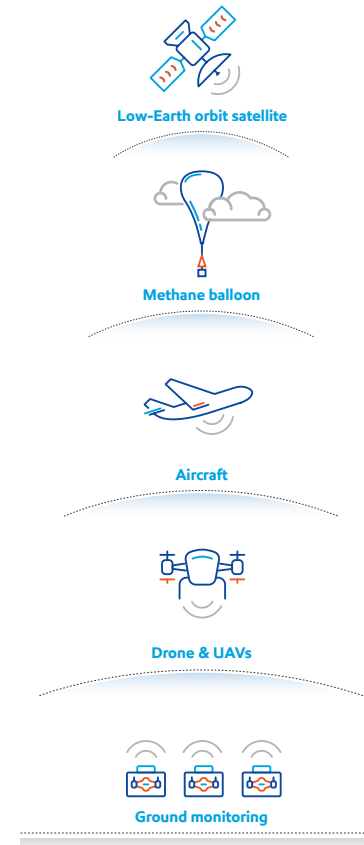
In March 2022, ExxonMobil joined others in our industry to launch the Aiming for Zero Methane Emissions Initiative. Our efforts support the goals of the Global Methane Pledge and the U.S. Methane Emissions Reduction Plan – as well as ExxonMobil’s 2050 net-zero ambition.

We’re implementing a multilayered approach that includes leading-edge technology to **monitor**, **measure**, and **mitigate** methane emissions.

### Monitoring and detection

In our ongoing efforts to target and eliminate methane emissions, we continue to develop and deploy enhanced technologies for rapid detection, mitigation, and quantification of sources of methane at our operated assets.

On the ground, in the air, and in space, the technology and processes we use to identify non-routine methane emissions provide us with a wide range of data points to inform and continuously improve our mitigation efforts. At this time, we’re advancing detection technologies in nine countries at operated assets that we estimate account for more than 80% of our methane emissions.



## Methods of detection

Method	Technologies	Detection thresholds*	Considerations	ExxonMobil sites**
Manual detection	<ul style="list-style-type: none"> <li>Handheld devices</li> <li>Portable detectors</li> </ul>	Less than 1 kg/hr	<p>Advantages: Precise location of emissions, using services already available in some locations</p> <p>Limitations: Labor intensive, periodic, and subject to human error. Does not provide quantification. No access to difficult-to-reach locations.</p>	<ul style="list-style-type: none"> <li>Permian Basin, U.S.</li> <li>Eagle Ford, U.S.</li> <li>Bakken, U.S.</li> <li>Appalachian Basin, U.S.</li> <li>Haynesville, U.S.</li> <li>LaBarge, U.S.</li> <li>Guyana FPSO</li> <li>Hebron, Canada</li> <li>Kearl Oil Sands, Canada</li> <li>Cold Lake, Canada</li> <li>Normal Wells, Canada</li> <li>Malaysia</li> <li>Nigeria†</li> <li>Angola†</li> </ul>
Facility-scale, near-continuous monitoring	<ul style="list-style-type: none"> <li>Fixed cameras</li> <li>On-the-ground sensors</li> </ul>	25 kg/hr – less than 1 kg/hr	<p>Advantages: Stationary monitoring, offering potential 24/7 coverage of an individual site, including duration of leaks.</p> <p>Limitations: Requires precise weather data for quantification. Additional research and innovation still needed to make this technology scalable.</p>	<ul style="list-style-type: none"> <li>Permian Basin, U.S.</li> <li>Freestone, U.S.</li> </ul>
Facility-scale, periodic monitoring	<ul style="list-style-type: none"> <li>Drones</li> <li>Mobile labs</li> </ul>	Less than 1kg/hr	<p>Advantages: Can cover multiple sites in their entirety, including areas unreachable by handheld devices.</p> <p>Limitations: Requires individual site visits. Airspace regulations may restrict drone use. Monitoring is not continuous.</p>	<ul style="list-style-type: none"> <li>Permian Basin, U.S.</li> <li>Freestone, U.S.</li> </ul>
Aerial detection	<ul style="list-style-type: none"> <li>Airplanes</li> <li>High-altitude platforms (i.e., balloons)</li> </ul>	50 kg/hr – less than 3 kg/hr	<p>Advantages: Can cover hundreds of sites per day, often using existing technology.</p> <p>Limitations: Additional detection often needed to identify sources within facilities.</p>	<ul style="list-style-type: none"> <li>Permian Basin, U.S.</li> <li>Eagle Ford, U.S.</li> <li>Bakken, U.S.</li> <li>Appalachian Basin, U.S.</li> <li>Haynesville, U.S.</li> <li>Germany†</li> <li>Australia†</li> </ul>
Satellite detection	<ul style="list-style-type: none"> <li>Low-earth orbit networks</li> </ul>	25,000 kg/hr – 100 kg/hr	<p>Advantages: Global, near-continuous coverage. Potentially lower cost.</p> <p>Limitations: High detection thresholds and sensitivity to environmental conditions.</p>	<ul style="list-style-type: none"> <li>Permian Basin, U.S.</li> <li>Cold Lake, Canada</li> </ul>

\*Detection thresholds vary depending on human and environmental factors, including weather and wind conditions.

\*\*Includes sites where these technologies have been piloted or deployed.

†Planning stages.

The technology to detect and quantify methane emissions continues to improve through collaboration and innovation supported by constructive government policy. While the current industry and regulatory approach on the ground is focused on manual leak detection, we're continuing to invest to develop and deploy technologies to increase the efficiency, precision, and coverage of our detection abilities.

For example, Project Astra is a collaboration of universities, environmental groups, and industry partners that is developing an innovative sensor network to continuously monitor methane emissions across large areas of Texas. This high-frequency monitoring system will give us the tools for quick leak detection and repair at specific locations, lowering costs and improving efficiency. After the completion of the first phase of the project in early 2023, the Department of Energy approved additional funding to extend Project Astra basin-wide.

Advances in facility-scale, near-continuous monitoring like this will enable sensitive, specific detection of methane emissions over time. Periodic monitoring using airplanes or drones can further expand coverage on land to dozens of onshore sites per day, depending on local conditions and logistics.

In the air, the moment-in-time observations provided by airplane surveys continue to be a valuable source of data, but we're going higher to enhance detection across larger areas on a more continuous basis.

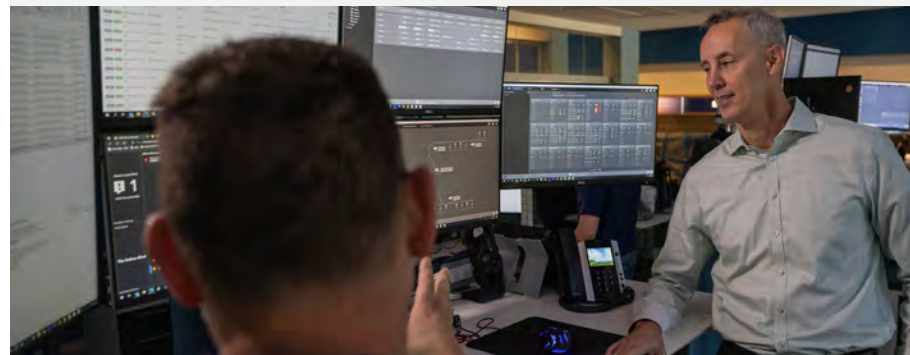
In 2023, we achieved an important milestone in our collaboration with Scepter, using a high-altitude balloon to test advanced imaging technology and proprietary data processing platforms to detect methane emissions across a large operating area in the Permian Basin. The data collected is the first of its kind, representing the first real-world demonstration of the potential for continuous methane monitoring over a broad region.

Finally, on the frontier of global emissions detection, we're venturing into space. We're working with Scepter and Amazon Web Services to develop satellite-based technology to design and optimize satellite placement and coverage, initially focused on capturing methane emissions data from our operations in the Permian Basin. Scepter anticipates increasing coverage with more than 24 satellites over three years, forming a large constellation network capable of monitoring oil and natural gas operations around the world.

## COMET: Bringing it all together in real time

Your home smoke detector serves an important purpose. When the alarm sounds you know that it has sensed a problem, whether it's smoke or just a low battery, you know that you need to respond. Our Center for Operations and Methane Emissions Tracking (COMET) operates on the same simple principle, scaled to cover massive acreages with diverse sources of data.

Launched in 2022, COMET is a \$20 million investment to centralize, continuously monitor and analyze methane emissions data from sources across our operations in the Permian Basin for rapid detection and mitigation. When fully deployed at all 700 operated sites across 1.8 million acres in the Permian, COMET will ultimately provide near-continuous, real-time monitoring in the region. With opportunities to expand outside the Permian Basin, COMET is a potential game changer for ExxonMobil and the industry.



## Our methane-reduction roadmap in the Permian Basin

Back in 2021, we became the first company to announce plans to achieve net zero by 2030 for Scope 1 and 2 greenhouse gas emissions from unconventional operated assets in the U.S. Permian Basin. Reducing methane emissions is a key part of that plan.

To date, we have focused largely on improving detection and response times to potential leaks, an effort that has led us to be recognized as an industry leader by the Environmental Defense Fund in its three-year direct measurement study in the Permian Basin.<sup>5</sup> Currently, remote operators receive automated alerts when an event is detected, analyze the data, and dispatch crews.

In the years ahead, we are focused on expanding these continuous monitoring and response capabilities, as well as automating the collection and analysis of data through integrated operations support centers like COMET to advance quantification of methane and analysis of trends over time.

## Measurement and reporting

We have reported our methane emissions publicly every year since 2014. This is an important part of our transparency efforts, and it enables us to work with academia, peers in our industry, and other stakeholders to continuously improve our shared understanding of methane emissions.

The data we report is based on internationally recognized methodologies and compiled each year by determining emissions by source at each operated asset across our company. With formal and informal guidance from frameworks like Veritas and the Oil and Gas Methane Partnership, our emissions data reporting improves each year, even as we've already begun the work of reducing the emissions themselves.

Methane is measured through interconnected processes. Snapshots of methane concentrations in the atmosphere provide, as described above, one input. Considering local weather patterns, the size and shape of an observed methane plume, and other environmental factors helps us model the rate and volume of the emissions. This process guides our timely mitigation efforts by identifying large or unexpected sources of methane.

## Understanding emission factors

Emission factors, consistent with regulatory reporting requirements and established by reputable third parties, help us to further understand our methane emissions. This standardized practice helps us to credibly estimate emissions, covering common sources across our business.

What are emission factors? Emission factors add to observational and other data to provide an estimate for average methane emissions. Classes of equipment, types of activities, or other variables are multiplied by the relevant emission factor to provide a credible estimate for our emissions inventory. Derived from sources like the American Petroleum Institute and the U.S. EPA Greenhouse Gas Reporting Program, emissions factors help oil and natural gas companies track methane emissions in a consistent way. As direct measurement and detection technologies evolve, emission factors are expected to be used less industry-wide.

We have long been a leader in advocating for strong measurement, reporting, and verification standards. Combined with the ongoing innovations in monitoring and detection, improvements in measuring and quantifying methane emissions are leading to a deeper understanding of emission sources and mitigation actions. We are focused on emissions mitigation and the transition to observation-based emission quantification of potential non-routine sources.

## Mitigating methane emissions

Our detection and quantification work continues to improve the accuracy of the methane volumes and intensity we report each year – and helps us assess the scale of the methane challenge and the effectiveness of the work we’re already doing. The framework we’ve established and shared has enabled the development of consistent and comparable data which, along with growing field measurements, guide our mitigation efforts.

The Methane Guiding Principles includes ExxonMobil’s framework as a resource for regulators in their Methane Policy toolkit, with potential applications across the natural gas value chain. We are proud of this thought leadership and our contribution to this challenge.

To lower our methane intensity, we are evolving the designs of our facilities, continuously improving our operations processes and protocols, and pursuing advanced technologies to meet the needs of our customers with fewer emissions.

Flaring is perhaps our most visible source of methane emissions because the flame can be seen by the naked eye. In 2022, flaring comprised about 14% of our operated methane emissions. It occurs as a safety measure when the volume of gas exceeds the capacity of our facilities. When these needs are anticipated and planned, we call that “routine flaring,” and we are working to eliminate this process from our operations.

We have committed to eliminate routine flaring in line with the World Bank Zero Routine Flaring Initiative in our operated assets by 2030 – something we achieved in our operated Permian Basin unconventional assets at the end of 2022. In addition to installing and upgrading our equipment, we continue to optimize our operations to eliminate routine flaring in the remaining locations.

Ongoing enhancements – large and small, complex and simple, proven and leading edge – are further accelerating our efforts to remove, reduce, or avoid methane emissions.

In some cases, we’re doing more with less, such as when we modify designs to eliminate components like pneumatic devices. In other circumstances, we’re simply doing the same things, but better. For example, we continue to improve the seals on centrifugal compressors and expand gas collection systems.

To put it succinctly, we take an approach where every feasible option is on the table as we explore and develop solutions to rapidly, safely, and reliably mitigate methane emissions.

## Replacing pneumatic devices

Pneumatic control devices have been used in the oil and natural gas industry for more than a century to operate valves that control liquid levels, pressure, temperature, and other process variables. By using natural gas from the production site, these devices safely and reliably perform their tasks in a wide range of extreme conditions around the world.

They also emit methane. Each time a pneumatic device is used, a small amount of methane is vented. Multiply this by the number of devices at each site, and it can add up. More than a third of our total methane emissions come from pneumatic devices, which is why we have eliminated “high-bleed” devices across our U.S. unconventional operated assets that vent methane at a higher rate and have made replacement of the rest a priority.

Unfortunately, there’s no one-size-fits-all solution to this challenge. In some cases, when reliable electricity is available, it’s as simple as installing an air compressor or a mechanical valve. In other cases, it means looking outside our industry, collaborating with others to enhance existing controllers and other technologies to mitigate or eliminate emissions. It can even mean using existing equipment in new ways, such as substituting nitrogen, which is an inert gas with no global warming potential, for operations instead of natural gas.

And the benefits extend beyond the individual piece of equipment. When retrofitting our existing assets, we often replace the infrastructure, which improves reliability and often further reduces opportunities for leaks and fugitive emissions.

Looking ahead, we’re continuing to conduct trials to test emerging solutions, deploy the most promising ones, and share what we learn with others to advance the shared ambition of near-zero methane emissions.

## Certified natural gas

As part of our methane management efforts, we continue to expand the volume of natural gas production that is independently certified by the nonprofit MiQ. The certification from MiQ verifies that our natural gas is produced with lower methane intensity, which helps us meet customer demand for energy produced with lower emissions, and it also helps us identify areas for improvement.

Over the course of 2022, our most recent year of full data, we increased our Permian Basin MiQ certified natural gas volume to approximately 700 million cubic feet per day produced from our facilities in Poker Lake, New Mexico. We have also successfully recertified our Appalachia facilities which produce approximately 300 million cubic feet per day. We are working to expand certification in other unconventional operated assets.



## Advocacy and collaboration

The energy industry is collaborative by nature. We work with industry partners and regulators around the world to advocate for strong and consistent measurement, reporting, and verification standards – and we collaborate with universities, industry groups, and others to advance the technologies and fundamental science related to methane emissions.

### Supporting sound policy

The model regulatory framework we published in 2020, and have shared broadly, provides a blueprint for industry-wide regulation, urging stakeholders, policy makers, and governments to develop comprehensive rules for methane emissions.

We work with the U.S. Environmental Protection Agency, the Bureau of Land Management, the Pipeline and Hazardous Materials Safety Administration, and others to encourage practical and effective regulation of methane emissions. In the United States alone, there are half a dozen agencies currently conducting important work on methane rulemaking, which, if not well coordinated, could lead to overlapping and potentially conflicting regulations. This is why we're focused on consistent regulation that incentivizes technology deployment and builds upon the industry-wide voluntary efforts that have been highly successful.

Our [model framework](#) for industry-wide methane regulations underpins our advocacy efforts, and in recent years, the commentary and guidance we've offered regulators includes:

- Comment letters to the U.S. EPA in [November 2019](#), [January 2022](#), and [February 2023](#) related to new source performance standards.
- A joint [comment letter](#) about continuous monitoring to the U.S. EPA, co-signed with five other companies in the energy, power, and aviation industries.
- Our [comment letter](#) to the Pipeline and Hazardous Materials Safety Administration on their proposed rules for leak detection.
- Testimony at the [U.S. EPA Methane Detection Technology Workshop](#).

### Teaming up to tackle methane emissions

We know we can't go it alone. Collaboration will be vital as we implement solutions to support society's net-zero future, and by working with a wide range of universities, academic consortiums, environmental groups, and more, we're advancing leading-edge research and piloting new technologies to help the industry and our company measure, reduce, and report methane emissions.

Among others, we're members of (\*ExxonMobil is a founding member):

- [Laboratory to Advance Methane Science\\*](#): A research collaboration with energy leaders to explore, discover, and quantify methane emissions, and develop solutions to reduce them.
- [Stanford Natural Gas Initiative\\*](#): A collaboration of more than 40 research groups from multiple disciplines working with industry partners and others to maximize the social, economic, and environmental benefits of natural gas.
- [Project Astra\\*](#): A partnership to monitor emissions across the Permian Basin with a first-of-its-kind sensor network, led by The University of Texas at Austin and bringing us together with the Environmental Defense Fund, Chevron, Pioneer Natural Resources Company, and GTI Energy, a research organization focused on energy solutions.
- [Veritas](#): GTI Energy's Methane Emissions Measurement and Verification Initiative, pursuing credible, comparable methane emissions measurement and accelerating actions that reduce methane emissions.
- [Project Falcon\\*](#): An industry partner study that aims to determine the best way to deploy fixed sensors for continuous methane monitoring at individual facilities.
- [The Environmental Partnership\\*](#): A collaboration among U.S. oil and natural gas companies of all sizes to take action on environmental performance, transfer knowledge, and foster collaboration among stakeholders.
- [World Bank Global Gas Flaring Reduction Partnership\\*](#): A multi-donor trust fund composed of governments, companies, and multilateral organizations committed to ending routine gas flaring at production sites across the world.
- [Methane Guiding Principles\\*](#): A partnership of more than 50 companies and organizations to enable action in industry and government to reduce methane emissions from the natural gas supply chain.

## Sharing knowledge and insight

Throughout our journey, we're sharing what we learned through [peer-reviewed publications](#) either co-authored by ExxonMobil or funded in part by the company. Since 2016, more than 23 articles have been published in academic and trade journals. Topics covered include tiered leak detection and repair programs, global to point-source methane emissions quantification, next-generation imaging, satellite capabilities, region-specific life-cycle greenhouse gas emissions of oil and natural gas, and much more.

Our work has been shared in technical briefings at venues like the American Geophysical Union and European Geophysical Union annual meetings, the American Petroleum Institute's Environmental Partnership meetings, and Stanford University's Methane Emissions Technology Alliance.

We've made significant progress, having cut our operated methane emissions in half since 2016, and we're not finished. By 2030, our methane-reduction plans include a 70%-80% reduction in corporate-wide methane intensity across our operated assets, and we are working to eliminate routine flaring in our global operated upstream assets in line with the World Bank Zero Routine Flaring Initiative. These efforts support the goals of the Global Methane Pledge and the U.S. Methane Emissions Reduction Plan, as well as our own 2050 net-zero ambitions.

## Footnotes

1. ExxonMobil's 2030 GHG emission reduction plans: [https://corporate.exxonmobil.com/news/news-releases/2021/1201\\_exxonmobil-announces-plans-to-2027-doubling-earnings-and-cash-flow-potential-reducing-emissions](https://corporate.exxonmobil.com/news/news-releases/2021/1201_exxonmobil-announces-plans-to-2027-doubling-earnings-and-cash-flow-potential-reducing-emissions). ExxonMobil's 2030 plans are expected to result in a 20%-30% reduction in corporate-wide greenhouse gas intensity, including reductions of 40%-50% in upstream intensity, 70%-80% in corporate-wide methane intensity, and 60%-70% in corporate-wide flaring intensity. Based on Scope 1 and 2 emissions of ExxonMobil operated assets (versus 2016). ExxonMobil's reported emissions, reductions, and avoidance performance data are based on a combination of measured and estimated emissions data using reasonable efforts and collection methods. Calculations are based on industry standards and best practices, including guidance from the American Petroleum Institute (API) and Ipieca. There is uncertainty associated with emissions, reductions, and avoidance performance data due to variation in processes and operations, the availability of sufficient data, quality of those data, and methodology used for measurement and estimation. Performance data may include rounding. Changes to performance data may be reported as part of the company's annual publications as new or updated data and/or emission methodologies become available. We are working to continuously improve our performance and methods to detect, measure, and address greenhouse gas emissions.
2. References to routine flaring herein are consistent with the World Bank's Zero Routine Flaring by 2030 Initiative/Global Gas Flaring Reduction Partnership's principle of routine flaring and excludes safety and non-routine flaring.
3. IPCC AR6 Report, Chapter 7: The Earth's Energy Budget, Climate Feedbacks and Climate Sensitivity (Table 7.15): [https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC\\_AR6\\_WGI\\_Chapter07.pdf](https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter07.pdf).
4. ExxonMobil methane emissions estimates as of year-end 2022.
5. <https://blogs.edf.org/energyexchange/wp-content/blogs.dir/38/files/2022/11/PermianMAPFinalReport.pdf>.