

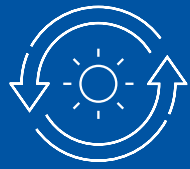
Climate change and the energy transition

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◆ **Not just a rock**
Understanding the subsurface is key to finding optimal locations for geological storage of captured CO₂. CCS is one of the intended levers to reduce our upstream carbon intensity and meet our climate ambitions.

Climate change and the energy transition



There is no one-size-fits-all solution to the energy transition challenge. Instead, there must be a multi-source, multi-speed approach that recognizes the different regional starting points in the energy trilemma – security, affordability, and sustainability. Among our international oil and gas peers, Aramco is in a leading position with one of the lowest upstream carbon and methane intensities.

We have an ambition to achieve net-zero Scope 1 and Scope 2 GHG emissions across our wholly-owned operated assets by 2050; by 2035, we aim to reduce our upstream carbon intensity by 15% against our 2018 baseline of 9.1 kg CO₂e/boe. We aim to meet our carbon intensity ambition and mitigate 52 MMtCO₂e annually by 2035 from our business as usual forecast emissions.

In 2023, we established the New Energies organization following the endorsement of our long-term strategy to achieve lower-carbon solutions and for Aramco to meet its GHG emissions mitigation and abatement ambitions. Over the next few years, we have allocated around 10% of our capital investments in New Energies to help us progress in our GHG emissions mitigation and abatement journey³.

2023 performance

Total Scope 1 and Scope 2 emissions¹ (million metric tons of CO₂e)



Upstream carbon intensity¹ (kg CO₂e/boe)



Upstream methane emissions (metric tons of CH₄)



2050 net-zero ambition

across wholly-owned operated assets

15%

reduction of Scope 1 and Scope 2 upstream carbon intensity emissions by 2035

** This figure has undergone external limited assurance in accordance to the ISAE 3000 (revised). The assurance report can be found [online](#) on the Sustainability section of our website.

- In 2023, along with the location-based methodology we have been reporting in our disclosures to date, we have also adopted a market-based methodology to calculate and report on our GHG emissions to avoid double counting of emissions associated with wheeled power, as per the GHG Protocol Scope 2 Guidance. Therefore, the figures reported for upstream carbon intensity and Scope 2 emissions are market-based. For 2023, the location-based figures for total Scope 1 and Scope 2 emissions and upstream carbon intensity are 72.6 MMtCO₂e and 10.7 kg CO₂e/boe, respectively. For 2022, the location-based figures for total Scope 1 and Scope 2 emissions and upstream carbon intensity are 71.8 MMtCO₂e and 10.3 kg CO₂e/boe, respectively. The 2021 Scope 2 emissions and upstream carbon intensity figures are reported using a location-based method. For more information on our GHG methodology, please refer to page 30 of this report.
- The Jazan Refinery is excluded from our GHG reporting in 2022 and 2021. In 2023, only the stabilized units of Jazan Refinery are included in our GHG reporting.
- Please refer to page 97 for more information on the New Energies organization.

Performance of our key metrics

Material issue	Relevant metrics	2023	2022	Status
Climate change	Scope 1 emissions (million metric tons of CO ₂ e)	54.4 ^{**2}	55.7 ^{**2}	Scope 1 emissions decreased by 2.3% compared to 2022 mainly due to lower hydrocarbon production during the year, and the use of more accurate emissions accounting methodologies for dynamic data at gas processing facilities.
	Scope 2 emissions (market-based) (million metric tons of CO ₂ e)	13.0 ^{**2}	10.3 ^{**2}	Scope 2 emissions (market-based) increased 26.2% and Scope 2 emissions (location-based) increase 13.0% compared to the previous year primarily due to the inclusion of the Jazan Refinery (stabilized units) in the 2023 GHG emissions inventory.
	Scope 2 emissions (location-based) (million metric tons of CO ₂ e)	18.2 ^{**2}	16.1 ^{**2}	
	Upstream carbon intensity (market-based) (kg CO ₂ e/boe)	9.6 ^{**}	9.3 ^{**}	Upstream carbon intensity (market-based) increased 3.2% and upstream carbon intensity (location-based) increased 3.9% compared to 2022, largely due to higher gas production, processing and storage, and lower overall hydrocarbon production.
	Upstream carbon intensity (location-based) (kg CO ₂ e/boe)	10.7 ^{**}	10.3 ^{**}	
	Upstream methane emissions (metric tons of CH ₄)	27,708	29,193	Upstream methane emissions decreased by 5.1% and upstream methane intensity was maintained at 0.05% despite increase in natural gas production. This was enabled by the Company's rigorous Leak Detection & Repair (LDAR) program, along with activities to decrease upstream flaring and enhance energy efficiency which reduce associated combustion related methane emissions.
	Upstream methane intensity (%)	0.05	0.05	
	Flaring intensity (scf/boe)	5.64 ^{**2}	4.60 ^{**2}	Flaring intensity in 2023 was 5.64 ^{**} scf/boe, up from 4.60 ^{**2} scf/boe in 2022, primarily due to increased maintenance and operational activities, as well as the inclusion of the Jazan Refinery (stabilized units) in the 2023 GHG emission inventory.
	Flared gas (MMscf)	27,506 ²	23,818 ²	
Energy intensity (thousand Btu/boe)	153.8	146.2	In 2023, Aramco's energy intensity was higher than 2022 by 5.2%, this was due to higher energy demand at our operationally controlled affiliates and at Jazan Refinery (stabilized units). Additionally, the increase in gas production, processing and storage impacted the energy intensity, along with lower overall production.	
Energy consumption* (MMBtu/hr)	85,649		Metric not disclosed previously, therefore no prior year comparative.	

■ Full metrics table on page 102

Our contribution to the UN SDGs



To support lower GHG emitting and more affordable energy, we are investing in 12 GW in solar and wind energy by 2030, expanding CO₂ storage capacity (e.g., carbon sequestration) as well as expanding gas production to displace the burning of liquids for power generation in the Kingdom.



Aramco Ventures was ranked as a Top-10 Climate Investor globally by Climate50¹. Aramco invests in lower-carbon-emitting energy and materials and in finding solutions to the climate challenges through its \$1.5 billion Sustainability Fund. This is expected to create jobs and contribute to economic growth.



As a major producer of oil and gas with one of the lowest upstream carbon and methane intensities among its industry peers, Aramco maintains its goal of mitigating and reducing GHG emissions across its wholly-owned operated assets through a range of initiatives, which include investments in innovative technologies. These efforts also ensure that we align with the Kingdom's ambitions on climate change.



In 2023 we planted 1.1 million native trees, and approximately 6.5 million mangrove trees in-Kingdom, bringing the cumulative total to 4.1 million native trees and over 30 million mangrove trees.



Aramco is collaborating with research centers and industries, aiming to find solutions for climate challenges, and partnering with organizations with a climate focus, such as the OGDC, OGCI, Ipieca and WEF, as part of a wide range of government and private sector collaborations across numerous industries.

* Metric reported for the first time externally.

** This figure has undergone external limited assurance in accordance to the ISAE 3000 (revised). The assurance report can be found [online](#) on the Sustainability section of our website.

- Acknowledging leading Climate Tech investor (Climate50).
- Jazan Refinery was excluded from our GHG reporting in 2022 and 2021. In 2022, we began reporting associated energy metrics. In 2023, in addition to the energy metrics, the stabilized units of Jazan Refinery were included in our GHG emissions and flaring metrics reporting.

Climate change and the energy transition continued

Our approach to climate change

As one of the world’s largest integrated energy and chemicals producers, we have scaled our operations to meet growing energy demand across the world, which has been driven by economic growth.

Aramco is always seeking ways to improve environmental performance by implementing projects to enhance energy efficiency and mitigate GHG emissions.

This forms an essential component of supporting the Kingdom’s target of net-zero by 2060, and our Company’s ambition to achieve net-zero Scope 1 and Scope 2 GHG emissions across our wholly-owned operated assets by 2050.

Our strategic focus is on developing and deploying innovative solutions, optimizing operations, and adopting efficient project designs that aim to mitigate our emissions. We have allocated financial, technological, and human capital to invest at scale to deliver these plans and ambitions. Innovation and new ways of thinking are driven by all levels of Aramco.

Climate change risk and mitigation

Climate change is a top corporate priority for us and we assess this on a medium- to long -term horizon. Our response to climate change is embedded in our business strategy, supported by our climate change and energy transition framework and our five GHG mitigation levers (energy efficiency, flaring and methane reduction, carbon capture and storage, renewables, and natural climate solutions and offsets).

Risk ¹	Mitigation
Policy: Policies restricting or banning use of fossil fuels, or applying a cost on carbon	<ul style="list-style-type: none"> Climate-related demand scenarios, leveraging our lower carbon intensity and GHG mitigation initiatives, to inform business decision making
Technology: Adoption of disruptive technologies and/or slow development of GHG reduction technologies	<ul style="list-style-type: none"> Accelerated development of our technology portfolios, including synthetic fuels, lower-carbon hydrogen production, liquids-to-chemicals, CCUS and CCS technologies
Market: Loss of demand for hydrocarbons as customers move to achieve their GHG targets	<ul style="list-style-type: none"> Diversification into lower GHG emitting products with longer life cycles, e.g., chemicals and materials supporting the energy transition
Legal: Potential exposure to climate-related litigation	<ul style="list-style-type: none"> Accurate and transparent reporting and disclosures with independent assurance.
Reputation: Impact on corporate reputation	<ul style="list-style-type: none"> Stakeholder engagement, including independent external consultants and subject matter experts to advise on reporting and disclosures, and explain the Company’s energy transition pathway

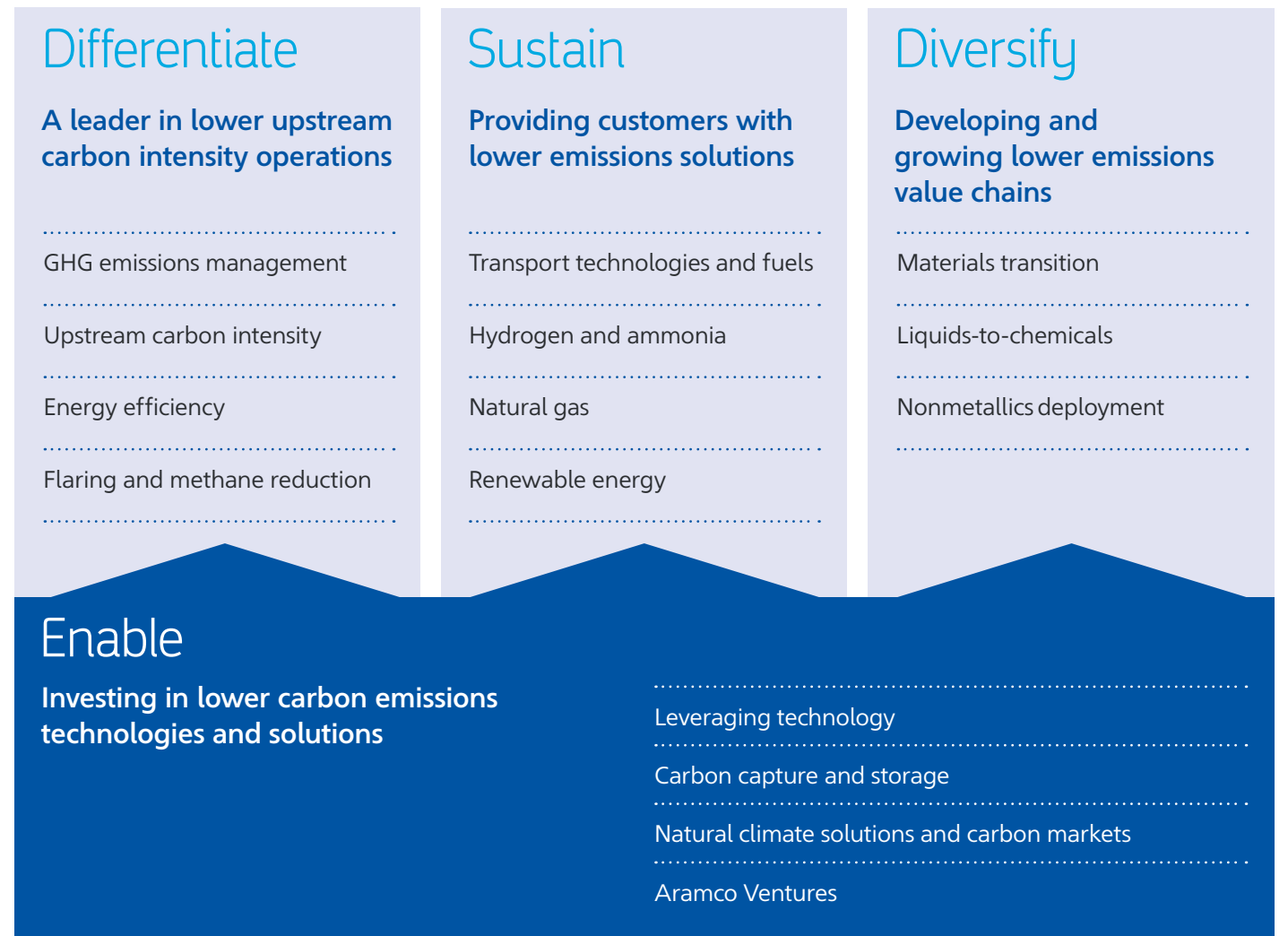
1. For more details, view “Managing Risk Exposure” section of the 2023 Aramco Annual Report.

Our climate change and energy transition framework

Our corporate strategy anchors on four strategic themes, two of which are upstream preeminence and lower-carbon initiatives, where we produce hydrocarbons that have one of the lowest upstream production costs and one of the lowest carbon intensities per barrel of oil equivalent in the world, while working with customers along the value chain to offer products that support their ambitions for the future.

Our climate change and energy transition framework is informed by the circular carbon economy principles of reduce, reuse, recycle, and remove.

We have four pillars that provide the framework for our climate change initiatives and investments:



A leader in lower upstream carbon intensity operations

Our upstream low carbon intensity provides Aramco with an inherent competitive advantage in the future energy landscape. It is the result of our unrivaled initiatives, which start at the subsurface.

These endeavors range from how we manage our reservoirs and the technologies we use to aid in water management, to our investment in megaprojects, infrastructure and digital solutions which help us reduce and manage our emissions at the surface.

Oil and gas reservoirs are thousands of feet below the surface. They are complex, made of different rocks and fluids, and are therefore dynamic. The technologies it takes to map, navigate and target specific zones in the subsurface is our specialty.

We devise field development plans to ensure the health and sustainability of our reservoirs using the latest technologies, while keeping our energy and emissions intensity in mind.

Managing emissions begins at the subsurface

All of our production strategies have enabled outstanding water management performance throughout our reservoirs over many decades. Produced water management plays a key role in lowering carbon intensity, by reducing energy demand to lift fluids, separate, treat, and dispose or reinject the produced water.

<p>Sustainable reservoir management</p>	<p>Advanced reservoir modeling (TeraPOWERS)</p>	<p>Geosteering and multilateral wells</p>	<p>Advanced smart well completions</p>
<p>Our philosophy of sustainable reservoir management is what sets us apart. Instead of maximizing production from our fields, we prioritize the long-term health of our reservoirs, and opt to produce at lower rates, which prevents premature water breakthrough and can potentially and irreversibly damage reservoirs.</p>	<p>To optimize our well placement and field development plans, we use advanced simulators, such as TeraPOWERS, which can predict water movement within the reservoir and help to optimize production efficiency.</p>	<p>Using real-time data, our engineers and scientists can steer multilateral wells with maximum reservoir contact, resulting in precise well placement. This helps target hydrocarbon zones, while minimizing the energy-intensive production of associated water.</p>	<p>Our production wells utilize advanced valves and devices, which can detect and manage unwanted water production at the subsurface. This reduces power consumption and CO₂ emissions.</p>

Investing in infrastructure, technologies, and digital solutions

Our investments in infrastructure to capture and reduce flared gas, along with our continuous development and deployment of digital solutions to monitor, manage, and reduce our energy intensity and flaring emissions sets us apart from most producers. In 2019, Aramco was benchmarked¹ with the lowest energy intensity among major oil and gas producers, and we have maintained a flare volume of <1% of total raw gas production since 2012.

<p>Master Gas System</p>	<p>Flare gas minimization and recovery</p>	<p>Digital solutions and real-time monitoring</p>	<p>Leak Detection & Repair (LDAR)</p>
<p>Launched in 1975, the Master Gas System is one of the biggest projects in Aramco's history, and has been integral to transforming the Kingdom's energy mix. The system allows the Company to utilize the gas it produces, rather than flaring it, and has resulted in an estimated annual avoidance of flared gas equivalent to 100 MMtCO₂e a year.</p>	<p>All our facilities have flare minimization roadmaps, and many of our plants are equipped with Flare Gas Recovery (FGR) systems to further reduce flaring.</p>	<p>Aramco deploys a vast array of digital solutions to optimize energy efficiency, including technologies of the Fourth Industrial Revolution (4IR), such as cloud computing, AI, and Big Data. These solutions allow us to monitor and mitigate flaring, reduce CO₂ emissions, and enhance productivity.</p>	<p>The LDAR is a robust program to proactively monitor and repair methane leaks. Millions of points are surveyed annually in every producing facility to ensure that we identify and swiftly repair any potential leaks. This is one of the reasons we achieved and continue to maintain our low upstream methane intensity (0.05%).</p>

1. Benchmark by Solomon Associates

Our net-zero ambition

Aramco's ambition is to continue to mitigate GHG emissions from our operations and achieve net-zero Scope 1 and Scope 2 GHG emissions by 2050 across our wholly-owned operated assets. We know that meeting our net-zero ambition while continuing to meet global energy demand will be a huge challenge.

Aramco is leveraging its R&D and technology initiatives to develop and implement innovative approaches that could help lower emissions across our industry and have potential application in other industries.

GHG emissions

We are aiming to abate 52 MMtCO₂e per annum by 2035 from our wholly-owned operated assets compared to our business-as-usual 2035 forecast emissions. This abatement will be achieved through energy efficiency projects, flare and methane minimization, carbon capture and storage, increasing renewable energy use, including the use of natural climate solutions, and using offsets to address hard to abate emissions in our operations.

The Company's GHG emissions management program monitors Scope 1 and Scope 2 emissions from wholly-owned operated assets, in a manner consistent with the GHG Protocol. As we strive for continuous improvement in our Sustainability Reporting, we have updated our methodology in line with the most up-to-date reporting guidance, with a view to enhance transparency and accuracy, and ensure we provide relevant data. To this end, we have adopted a market-based methodology approach alongside our location-based approach to calculate applicable GHG emissions to provide a more accurate inventory.

Under the market-based methodology, for 2023 our Scope 2 emissions are 13.0** MMtCO₂e (as compared to 18.2** MMtCO₂e under a location-based method).

Our 2035 interim ambitions and associated GHG emissions mitigation levers have been developed for Scope 2 emissions based on a market-based approach.

Aramco plans to report both location-based and market-based approaches to ensure transparency in comparison with previous years.

Total Scope 1 and Scope 2 emissions¹
(million metric tons of CO₂e)



Upstream carbon intensity¹
(kg CO₂e/boe)



In 2023, total Scope 1 and market-based Scope 2 GHG emissions increased by 2.0%, equivalent to 1.3 MMtCO₂e in 2023 compared to the previous year. Scope 1 emissions decreased by 2.3% compared to 2022 mainly due to lower hydrocarbon production during the year, and the introduction of a revised CO₂ venting emissions methodology for gas processing operations to account for dynamic CO₂ concentrations, resulting in a more accurate accounting methodology. Scope 2 emissions (market-based) increased by 26.3% compared to the previous year primarily due to the inclusion of the Jazan Refinery (stabilized units) in the 2023 GHG emissions inventory, and an increase in gas production.

In 2023, we completed bottom-up assessments of our assets, to better identify and prioritize opportunities to meet our interim and 2050 climate ambitions. These assessments are supported by ongoing efforts including energy optimization and energy efficiency.

Upstream carbon intensity

An important metric for Aramco is the carbon intensity of upstream operations, which is among the lowest relative to major crude oil producers per barrel of oil equivalent and has been achieved through effective reservoir management, a low depletion rate operational model, and a focus on energy efficiency.

Our 2035 upstream carbon intensity target of 15% reduction from a 2018 baseline remains unchanged. Adopting a market-based methodology, our target is now 7.7 kg CO₂e/boe (using the 2018 baseline of 9.1 kg CO₂e/boe). Under our previously reported location-based methodology, the target was 8.7 kg CO₂e/boe (using the 2018 baseline of 10.2 kg CO₂e/boe).

In 2023, our upstream carbon intensity (market-based) was 9.6** kg CO₂e/boe (as compared to 10.7** kg CO₂e/boe under location-based method), and increased 3.2% compared to 2022, largely due to lower upstream production and other operational activities, including increased gas production and storage.

Gas is more energy and carbon intensive to produce, yet it provides lower emitting fuel for the power sector when displacing liquids. The storage of gas which commenced in 2023, impacts the upstream carbon intensity. The gas which is produced and stored is removed from the volume of hydrocarbon marketed, and thus increases the upstream carbon intensity.

** This figure has undergone external limited assurance in accordance to the ISAE 3000 (revised). The assurance report can be found [online](#) on the Sustainability section of our website.

1. The 2023 and 2022 figures for Scope 2 emissions and upstream carbon intensity are reported using the market-based method. The 2021 figures for Scope 2 emissions and upstream carbon intensity are based on the location-based method.
2. The Jazan Refinery is excluded from our GHG reporting in 2022 and 2021. In 2023, only the stabilized units of Jazan Refinery are included in our GHG reporting.



As part of our ongoing initiatives to address carbon intensity we have delivered a first pilot shipment of 2MM bbl of Arabian Light crude oil with a product level carbon emissions. This first shipment entailed the calculation of a total carbon intensity of 6.39** kg CO₂e/boe, of which the production and loading stages were 2.42** kg CO₂e/boe, demonstrating the inherent competitive advantage of our lower upstream carbon intensity.

Value chain emissions

While our focus is on the management of GHG emissions from our wholly-owned operations that are within our direct control, we also support the energy transition through developing technologies that aim to lower-GHG emissions.

Our investment in hydrogen, chemicals, and renewable energy sources and the increasing share of gas in our production are intended to provide lower emissions products and energy to our customers. We continue to invest in a number of product stewardship partnerships and technologies to reduce emissions, including research and development into lower emissions transport solutions.

Our \$1.5 billion Sustainability Fund, which invests in breakthrough technologies and startups to find solutions to complex climate challenges, is evidence of our holistic approach and support to the energy transition.

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Sustainability in action

The Oil and Gas Decarbonization Charter (OGDC) launches at COP28

In December 2023, the United Arab Emirates' COP 28 Presidency and the Kingdom of Saudi Arabia established the landmark Oil and Gas Decarbonization Charter (OGDC). Aramco played a key role in the development of the OGDC. The objectives of the charter are to align the oil and gas industry on various key areas, which include:

- Aiming to reach net-zero emissions (Scope 1 and 2) for operations under control by 2050;
- Aiming for near-zero upstream methane emissions by 2030; and
- Aiming for zero routine flaring by 2030.

Signatories of the OGDC included than 50 companies that represent more than 40% of global oil production.

For more information please click [here](#).

Differentiate | Sustain | Diversify | Enable

Levers to meet our interim climate ambition

To mitigate 52 MMtCO₂e from our business as usual emissions by 2035, we are focusing on five key levers: energy efficiency across our upstream and downstream assets; further reductions in methane and flaring; increased use of renewable energy sources; CCS; and development or purchase of offsets to help address hard-to-abate emissions.

In 2023, detailed studies at the asset-level were completed, and have enabled Aramco to update the mix of abatement opportunities across all five levers while also supporting our 2035 mid-term ambition and its associated abatement of 52 MMtCO₂e. Furthermore, the redistributed mix of abatement across levers optimizes cost and capitalizes on synergies.

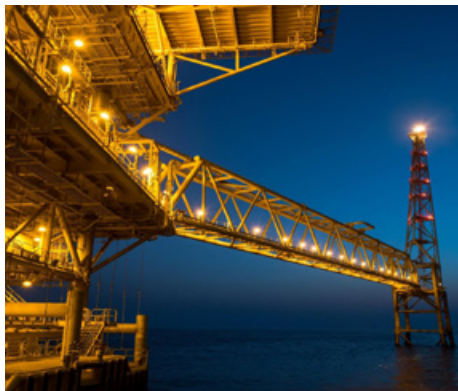
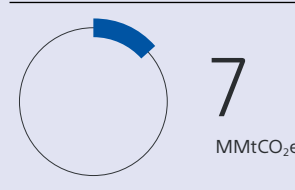


Energy efficiency

Since energy efficiency continues to be at the heart of our work at Aramco, the planned abatement associated with energy efficiency has been refined from 11 MMtCO₂e to 7 MMtCO₂e. This reduction can be attributed to the detailed studies at the asset level completed in 2023 and Aramco's long-standing Energy Management Program, which started in 2000 and has achieved a cumulative emissions reduction of 31.43 MMtCO₂e.

Our actions in 2023

- Implemented 110 energy efficiency initiatives resulting in energy savings of 6,700 boed, and the avoidance of 0.73 MMtCO₂e
- Implemented an ambitious cogeneration transformation program to improve operational efficiency reducing corporate energy intensity by 23% and recognized as a best practice case study by the World Economic Forum
- Developed an advanced energy demand forecasting solution for 26 operational facilities
- Optimization of operation and controls for gas processing, gas turbines, and compressors
- Enhanced boiler and pump efficiencies
- 40 Aramco organizations have received the ISO 50001 certification for their energy management systems

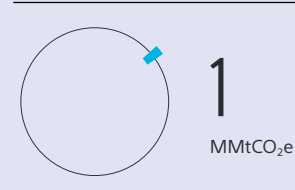


Flaring and methane

Aramco is among industry leaders in both upstream methane and flaring intensities due to decades of investments in digital and engineering solutions.

Our actions in 2023

- 8.9 billion scf of flare gas was recovered in 2023 due to more efficient operations of FGR systems across several facilities
- Maintained upstream methane intensity of 0.05% despite expansion in gas production
- Enhancements in flaring minimization roadmaps resulted in avoidance of 527 MMscf from Midyan and Uthmaniya Gas Plants
- As part of Leak Detection & Repair program, millions of components were surveyed across our facilities to identify potential methane leaks and 1,800 repairs were conducted.
- Deployed a satellite methane monitoring campaign for key upstream assets to monitor methane emissions

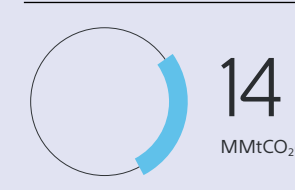


Carbon capture and storage

Aramco is advancing technologies for both CO₂ capture and storage, and investing in world-scale CCS capabilities. We plan to store up to 14 MMtpa by 2035 – contributing towards the Kingdom reaching its goal of 44 MMtpa of CCUS by 2035.

Our actions in 2023

- The CCS lever has been increased from 11 MMtCO₂e to 14 MMtCO₂e, as Aramco is seeking opportunities from scope-optimization to enhance the CCS lever
- Continued development of CCS, Aramco has a target to store 14 MMtpa by 2035, of which 6MMtpa is planned at the Jubail CCS Hub. Phase 1 of the project targets to store up to 9 MMtpa by 2027, of which 6MMtpa is dedicated to Aramco and 3MMtpa to non-Aramco facilities
- Piloted a novel CO₂ geological sequestration solution in collaboration with KAUST, using in-situ mineralization by injecting in basalt formation, permanently converting CO₂ into carbonate rocks
- Established collaboration with Siemens Energy to develop a Direct Air Capture unit in Dhahran. The unit is expected to be completed later in 2024

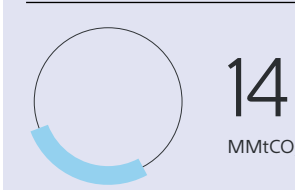


Renewables

Aramco has a target to invest in up to 12 GW of solar and wind energy by 2030, and is exploring for geothermal energy in the Kingdom. We are also investing in advancing renewables technology.

Our actions in 2023

- Reached full capacity and commercial operation at the Sudair Solar PV plant, one of the largest solar plants in the region with a capacity of 1.5 GW¹, in January 2024
- Entered into an agreement for two solar PV projects – Al Shuaibah 1 and Al Shuaibah 2, which will generate an aggregate capacity of over 2.7 GW¹ of renewable electricity. Commercial operations are expected to commence in 2025
- Continued exploring geothermal energy opportunities and identified three potential areas on the west coast of Saudi Arabia
- Deployment of solar PVs as the power source in remote drill sites and offshore platforms

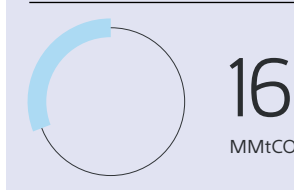


Natural climate solutions and offsets

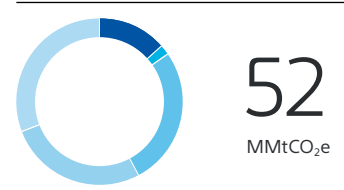
Aramco continues to assess opportunities to expand our in-Kingdom mangrove planting efforts and is now evaluating the suitability of inland mangrove planting within the Kingdom. Beyond this, Aramco is evaluating additional opportunities for planting mangroves outside the Kingdom, and will continue to complement our plantation efforts with high quality carbon credits as feasible to build a portfolio of carbon offsets that aim to address hard-to-abate emissions.

Our actions in 2023

- Planted approximately 6.5 million mangrove trees in-Kingdom, which brings the cumulative total to over 30 million mangrove trees. Third-party validated total carbon stock of planted and existing mangroves equals nearly 445,000 tons of CO₂e cumulatively since we started our mangroves plantation in 1993
- Participated as a lead bidder in the largest voluntary carbon credit auction in Nairobi, Kenya and purchased one million credits of recent vintages
- Retired around 500,000 carbon credits, equivalent to 0.5 MMtCO₂e, against corporate emissions



GHG emissions mitigation by 2035



1. For solar energy projects: Sudair solar plant's capacity 1.5 GW AC is equal to 1.8 GW DC; capacity of Al Shuaibah 1 and Al Shuaibah 2 solar PV projects is 2.7 GW AC, which is equivalent to 3.2 GW DC.

Energy management and energy efficiency

Aramco started its energy management program to improve energy performance in 2000. Since 2013, Aramco operations' energy intensity has improved by 13.4%. In 2022, we expanded the reporting of our energy intensity metric by including our operationally controlled affiliates both global and in-Kingdom.

In 2023, Aramco's energy intensity was 5.2% higher than in 2022. It is noteworthy that the accounted increase in energy demand is not coupled by an increase in accounted production associated with refineries and some affiliates. There was a 6.5% increase in energy demand at our operationally controlled affiliates. Additionally, Jazan Refinery's stabilized units were also added to the measured energy demand in 2023. The increase in gas production, processing and storage² impacted the energy intensity, along with lower overall production.

Energy efficiency actions:

- Commissioning of combined cycle steam turbine generator at Shaybah Producing facility avoiding 75.6 MtCO₂e per year;
- Reduction of steam reserve at Abqaiq Plants avoiding 44 MtCO₂e per year;
- Optimization of chilled-down operation at Berri Gas Plant avoiding 22.6 MtCO₂e per year;
- Energy Efficiency Enhancement Study to optimize power demand at Manifa field resulted in 552 MWh electricity reduction in 2023 equivalent to 0.38 MtCO₂e per year;

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Aramco organizations received ISO 50001 certification for their energy management systems

Cogeneration plants, operational energy optimization, equipment load management, and upgrades to more energy-efficient equipment have all contributed to improving energy performance.

Energy intensity¹ (thousand Btu/boe)



- Continued optimizing HVAC and controls in buildings to enhance energy efficiency; and
- 40 Aramco organizations have received the ISO 50001 certification for their energy management systems.

For the non-industrial sector, Aramco is embarking on Energy Performance Contracting (ESCO) initiative to accelerate enhancing the energy performance of its built environment. Phase-I of the ESCO deployment has been completed by awarding and signing the Aramco's first ESCO pilot project for the Dammam Office Buildings. Accordingly, energy savings quick wins in 100 targeted buildings were completed as a prerequisite to commence Phase-II of ESCO deployment in these buildings. The Phase-II is expected to be completed by 2025.

Cogeneration

Our investments in cogeneration facilities have contributed to significant improvements in energy efficiency for both our operations and the national grid, where we export some of the generated power. Highly efficient cogeneration plants enable us to produce electricity for our operations utilizing what would otherwise be wasted heat/energy, and are enabling self-sufficiency in electrical power generation for our own operating plants. We analyze the real-time data of the power generated, which allows us to further enhance energy efficiency.

We are harnessing what would otherwise be waste energy by maximizing the conversion of energy released from the combustion of fuel into power and steam to achieve improved thermal energy efficiency and reduce overall GHG emissions. In 2023, we achieved an average thermal efficiency of 71.0% (70.7% in 2022) in our interconnected cogeneration facilities. Several energy optimization studies were carried out for the existing facilities and capital projects. The studies identified energy efficiency initiatives including optimum driver options, heat integration, and deployment of waste heat recovery technologies.

Although having a large fleet of cogeneration plants (fleet size 8MW) significantly reduces the Kingdom's overall GHG emissions, it contributes to our Company's Scope 1 emissions as not all generated power is consumed by Aramco, but some is exported to grid, lowering the Kingdom's overall grid emission factor.



Award

Safaniya Offshore Producing and Uthmaniya Gas Plant win the Clean Energy Ministerial Energy Management Leadership Award

The Global Energy Management Leadership Awards recognize leading organizations for their energy management achievements and raise the profile of the ISO 50001 energy management systems as a proven, broadly applicable solution to global energy and climate change challenges.



Sustainability in action

Aramco's cogeneration facilities recognized by the World Economic Forum

According to the World Economic Forum, the global manufacturing and production sector is responsible for nearly 20% of global carbon emissions, making it crucial for industries to increase energy efficiency to reduce GHG emissions and preserve resources.

Aramco has historically relied on Saudi Arabia's national power grid for power. In order to drive operational efficiency improvements across our operations, we are implementing an ambitious cogeneration transformation program to improve operational efficiency, by utilizing the energy of waste heat, thereby reducing energy consumption from the Kingdom's national grid.

The program has installed 17 high-efficiency cogeneration facilities, reducing CO₂ emissions by approximately 7 million tons annually between 2011 and 2022, and lowering corporate energy intensity by 23%.

This initiative was selected as a best-practice case study in reducing industrial energy intensity in the World Energy Forum's whitepaper titled Transforming Energy Demand. The whitepaper highlights Aramco's 'Lead by Example Program', which has improved energy efficiency in non-industrial sectors like communities, buildings, and transportation services by retrofitting low-efficiency assets, resulting in a 27% reduction in non-industrial energy sector use.



Sustainability in action

Embracing 4 IR to become even more energy efficient

Aramco has developed an advanced Energy Demand Forecasting Solution. The solution utilizes the latest 4IR digital capabilities such as artificial intelligence, advanced analytics, and machine learning for the purpose of forecasting the future energy demand and associated CO₂ emissions in our industrial facilities, with an accuracy of up to 99%. This forecasting solution will help develop strategies to enhance future energy performance, while reducing associated CO₂ emissions.

Highlights

- Reducing corporate energy intensity by 1% -1.2% through effective monitoring and target setting at facilities where Energy Demand Forecasting Solution is implemented.
- Supporting corporate GHG emissions mitigation and digitization efforts
- Up to 99% prediction accuracy of energy demand based on production plans

This solution was developed for 26 operational facilities.



** This figure has undergone external limited assurance in accordance to the ISAE 3000 (revised). The assurance report can be found [online](#) on the Sustainability section of our website.

1. As we progress on our reporting journey and our controls around ESG data mature, for this metric from 2022 onwards, we have expanded the reporting boundary from Company in-Kingdom to operational control. The 2021 figure is at a Company in-Kingdom level only.

2. The activity of compressing sales gas for injection and storage underground increases energy demand, while gas storage decreases sold hydrocarbon going into the calculation, increasing the reported energy intensity.

Flaring

Although flaring is required at oil and gas processing facilities for safety purposes, for decades we have been creating solutions to reduce such flaring, from larger infrastructure such as our Master Gas System and installing flare gas recovery systems at many of our plants, to developing innovative digital solutions.

Our flare monitoring system is one example. It addresses the challenges related to monitoring and reducing flares. The solution provides Company-wide, real-time monitoring capabilities of all flare sources at an asset level.

Our flaring intensity in 2023 was 5.64** scf/boe, up from 4.60** scf/boe in 2022, primarily due to increased maintenance and operational activities, as well as the inclusion of the Jazan Refinery's stabilized units in the 2023 GHG emission inventory and flaring metrics reporting.

Highlights

- Aramco FGR systems in several facilities were performing with high availability and reliability which resulted in the recovery of 8.9 billion SCF of flared gas in 2023.
- Continuous implementation of Flaring Minimization Roadmaps, which lay out site-specific priorities across Aramco operations to further reduce flaring. In 2023, the roadmaps resulted in avoidance of 527 MMscf from Midyan and Uthmaniya Gas Plants.
- Investing in and developing innovative flaring reduction technologies.
- Implementing new FGR projects for applicable operational facilities – a major technology for flare minimization. The implementation and further enhancement of FGR system at Fadhli Gas Plant and Manifa Producing Plant avoided flaring of 1,396 MMscf.

Flaring intensity (scf/boe)



Flared gas (MMscf)



Award

Khurais Producing Department wins the 2023 SEAL Business Sustainability Award

Khurais received the international Sustainability, Environmental Achievement and Leadership (SEAL) Business Sustainability Award¹ for their initiatives on GHG emissions mitigation, water conservation, and granted patents. Obtaining such recognition, is a continuation of Khurais's journey to reduce emissions, leveraged by the department's workforce and advanced technologies.

Methane

Methane is a potent GHG with a higher global warming potential than CO₂ and thus managing it is a priority for Aramco and the oil and gas industry.

As part of the OGCI, members set a target to reduce methane emissions from oil and gas operations. We have surpassed the 2025 OGCI target of well below 0.20% already (we are at 0.05%) and continue to take actions to further drive down our methane intensity.

Our upstream methane emissions decreased by 5.1% despite an increase in natural gas production. This was due to cumulative process efficiency enhancements, including the installation of FGR systems, high efficiency flare systems and adoption of strict Flare Minimization Plans to reduce flaring volumes and the rate of process gas sent to the flare, thereby maintaining optimal combustion efficiency at

flare headers and reducing methane emissions. Other process enhancements included application of Advanced Process Control (APC) systems to optimize system efficiency and energy demand, minimizing fuel gas consumption and associated combustion related methane emissions.

Furthermore, our comprehensive Leak and Detection and Repair (LDAR) program contributes significantly to reducing fugitive methane emissions through the systematic identification and repair of continuous minute gas leaks. This year all Upstream assets were surveyed and millions of components were monitored to identify equipment that need repairs.

A total of 1,800 repairs were conducted in 2023 for both Upstream and Downstream assets. The reduction in absolute methane emissions is also attributed to enhancements in the methane emissions methodology to account for actual activity data, and the ongoing LDAR program.

GHG Satellite Monitoring

Aramco is constantly seeking ways to enhance GHG emissions monitoring and mitigation. The GHGSat Satellite Constellation, a network of satellites, is currently being deployed after extensive trials and a program launched in 2023 to identify and monitor methane emissions from Aramco's in-Kingdom operations. As part of our aim to monitor emissions, we are using this cutting-edge space-based sensor technology to identify and mitigate emissions sources at a very detailed level of accuracy while supporting LDAR activities.

Upstream methane intensity (%)



Upstream methane emissions (metric tons of CH₄)



Sustainability in action

Haradh gas plant reduces flaring by 11%

Haradh gas plant reduced plant flaring by 11% as a result of the following initiatives:

- Purge gas optimization study.
- Optimized the Hydrocarbon Thermal Oxidizer maintenance duration and reduced the flared amount during the maintenance by 70 MMscf.
- Mitigated leaks from flare control valves.
- Deployed online cleaning methodology for stabilization system reboilers that eliminate equipment isolation and depressurization.



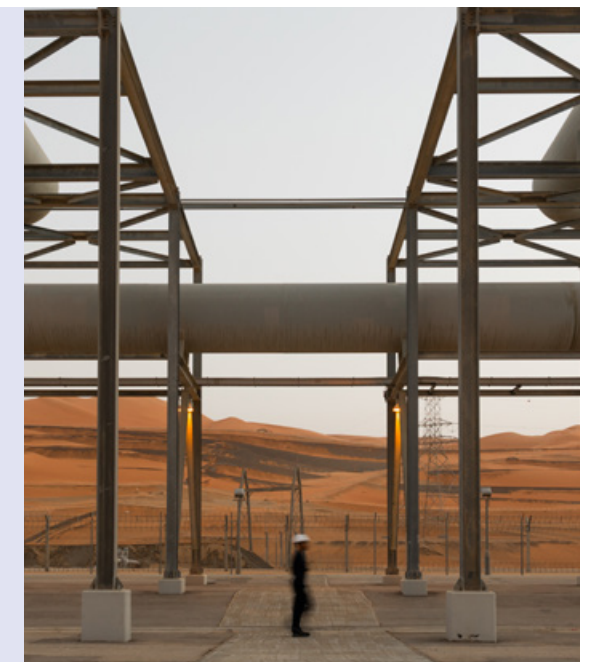
Sustainability in action

New methane emissions detection technology piloted

In 2023, two new technologies were piloted at Hawiyah NGL Plant for continuous monitoring of methane emissions:

- A Tunable Diode Laser Absorption Spectroscopy Methane Detection System
- A remote sensing Fourier Transform Infrared spectroscopy system.

The newly piloted technologies will further increase our expertise in the field of continuous methane emission monitoring, while enhancing our performance in the LDAR Program, and prioritizing methane mitigation actions at our operating facilities. Continuous methane monitoring is a fast-evolving field in the oil and gas industry with multiple new emerging methane detection and quantification technologies.



** This figure has undergone external limited assurance in accordance to the ISAE 3000 (revised). The assurance report can be found [online](#) on the Sustainability section of our website.
 1. The Jazan Refinery is excluded from our GHG and flaring reporting in 2022 and 2021. In 2023, only the stabilized units of Jazan Refinery are included in our GHG and flaring metrics reporting.

Providing customers with lower emissions solutions

Fuels and transport technologies

Transportation is a core element of the energy transition. Aramco is exploring the development of synthetic fuels that produce lower GHG emissions and maintain the same levels of performance. Aramco's lower carbon intensity crudes and investment in GHG emissions mitigation initiatives in our refineries enable production of fuels with lower embedded carbon. We are also exploring ways to improve the efficiency of the internal combustion engine.

We recognize that achieving successful GHG emissions mitigation of the automotive industry necessitates a combination of various technologies. These could include highly efficient internal combustion engines (ICE), hybrid, synthetic fuels, hydrogen, and electric vehicles (EVs). To effectively reduce GHG emissions from transportation, it is crucial to invest in enhancing the efficiency of ICE vehicles, considering that by 2050, approximately 56% of vehicles are expected to still rely on this technology. Lower-carbon emission ICE vehicles and alternative fuels technologies have the potential to reduce emissions by 50-75%. Furthermore, lower-carbon emissions ICE vehicles and alternative fuels technologies are expected to play a key role in lowering GHG emissions in regions where the power grid relies heavily on coal as well as helping to alleviate strains on critical minerals supplies and grid capacity associated with electrification.

Our Transport R&D team have presence all around the world, including in Paris, Detroit, and Shanghai, and our research centers act as technology hubs to leverage the respective innovation ecosystems in each region. Scientists and technologists across the centers are working closely with technology providers and automakers to advance practical solutions for a more sustainable mobility future.

In 2023, at the Bahrain Grand Prix races, Aramco supplied fuels containing 55% bio components for the first competitive use, which were used in Formula 2 and Formula 3 cars. This is a transitional step as the championships work toward ambitions by 2027. Our intention is to introduce synthetic components to the formulation from 2025 onwards.

Aramco and ENOWA, NEOM's energy and water company, signed a joint development agreement to construct and establish a first-of-its-kind synthetic fuel demonstration plant. The project will be located in ENOWA's Hydrogen Innovation and Development Center (HIDC) and aims to demonstrate technical feasibility and commercial viability of synthetic gasoline from renewable-based hydrogen and captured carbon dioxide. The demonstration plant in NEOM is the result of intensive research and development efforts aiming to optimize the production of synthetic fuels.

In Bilbao, Spain, Aramco and Repsol are exploring the production of synthetic diesel and jet fuel for automobiles and aircrafts.

We have also been carrying out extensive research into the potential of algae-based biofuel, and have produced the first batch of biocrude from microalgae. Our efforts are part of a wider exploration of how we can make more use of nature-based solutions in our operations. For example, we are exploring how algae-based products could potentially be used in our upstream operations, including drilling. We are exploring ways to convert algal biocrude into drilling fluids, such as oil-based muds.

Lower carbon aviation fuel

As the global aviation industry works towards addressing its GHG emissions and net-zero ambitions, aviation fuels, notably Sustainable Aviation Fuels (SAF) may account for a 65%¹ share of measures to address this ambition. However, there are current challenges with scaling the production and deployment of SAF required to meet industry targets. For example, the cost of SAF is currently 3 to 5 times the cost of jet fuel and substantial upfront investment costs will be required for SAF facilities.

Aramco is working towards being a provider of lower carbon aviation fuels (LCAF), which have lower carbon intensity compared to the global average for jet fuel and are compatible with existing fueling infrastructure. This could offer a viable transitional and complimentary to SAF solution while also providing the added benefit of having 10% lower GHG emissions compared to conventional jet fuel.

LCAF can be incorporated as a fossil-based aviation fuel that meets the United Nations International Civil Aviation Organization, Carbon Offsetting and Reduction Scheme for International Aviation (CORSA).

Hydrogen and ammonia

Aramco is championing the Kingdom's ambition to be a world-leading producer of efficient fuels, through a plan to produce 11 MMtpa of blue ammonia by 2030. Aramco's CCS development is instrumental to both production of hydrogen and the resulting CO₂ being captured and sequestered, and facilitating the Kingdom's GHG emissions mitigation ambitions.

In 2023, a first shipment of independently-certified blue ammonia was delivered to Japan for use as fuel in power generation with the resulting CO₂ being captured and sequestered.

The shipment was the result of a successful multi-party collaboration across the lower-carbon ammonia value chain. The ammonia was produced by SABIC Agri-Nutrients with feedstock from Aramco, and sold by Aramco Trading Company to the Fuji Oil Company. Mitsui O.S.K. Lines was tasked with shipping the liquid to Japan, then the ammonia with the resulting CO₂ being captured and sequestered was transported to the Sodegaura Refinery for use in co-fired power generation, with technical support provided by Japan Oil Engineering Co.

Ammonia is significantly more convenient, practical and cost-effective than hydrogen in its transport, both in terms of the required temperatures and pressure conditions. We are helping chart a course for this vital commodity, which is also an important energy source in its own right that will help to mitigate GHG emissions in key sectors.



Sustainability in action

Aramco delivers lower carbon aviation fuels

Aramco's jet fuel production in the Kingdom of Saudi Arabia has a lower carbon intensity (CI) than conventional jet fuel compared to the global average and is compatible with existing fueling infrastructure and procedures. In view of addressing GHG emissions in the aviation sector, LCAF is envisaged to hold complementary roles and be a part of the aviation fuel mix along with other alternative fuels such as SAF and synthetic fuels. Aramco has recently completed the validation of the CI of its jet fuel production from some of its in-Kingdom refineries and is subsequently working towards LCAF certification, as per requirements from the Carbon Offsetting and Reduction Scheme for International Aviation (CORSA).



Sustainability in action

Aramco contributes to a credible hydrogen market

The Open Hydrogen Initiative is led by GTI Energy, S&P Global Commodity Insights, and in partnership with the United States Department of Energy to lay the foundation for hydrogen markets by creating objective, peer-reviewed, and open-sourced tools to measure and assess the carbon intensity of hydrogen production at the facility level.

In line with the Company's strategic theme of pursuing lower-carbon initiatives, Aramco is collaborating with more than 40 other organizations spanning industry, environmental NGOs, academia, and government entities to develop a first-of-a-kind framework to advance efforts to reduce carbon emissions of this energy sector and be a player in supporting a transparent, credible, and harmonized hydrogen market.



1. Source: IATA. Net-zero 2050: sustainable aviation fuels (iata.org)



Sustainability in action

Building the first underground gas storage facility in the Kingdom

Raising our gas production is an essential part of our long-term strategy, allowing us to drive emission reductions in the Kingdom by displacing the burning of oil liquids in electricity generation.

However, domestic electricity demand is typically seasonal, with consumption in the peak summer months significantly higher than that in the winter months. To meet this challenge and to avoid the need to use higher emission energy sources to meet short term demand spikes, gas storage is key.

The Hawiyah Gas Compression and Storage Facility – which is based in the middle of the world’s largest onshore oilfield – receives gas from our Master Gas System, an extensive network of pipelines connecting Aramco’s key gas production and processing sites with customers throughout the Kingdom. The received gas is then compressed and injected underground into the depleted Unayzah reservoir, ready to be stored until needed, at which point it is re-injected into the Master Gas System.

Hawiyah is designed to inject up to a 1.5 bscfd and has the capacity to withdraw up to 2.0 bscfd of the stored sales gas.



Natural gas

Natural gas is a key enabler for the energy transition, as it is highly compatible with intermittent renewable energy for power generation, and provides more efficient power than other conventional forms of non-renewable energy.

Our gas investment is key to the Kingdom’s plan to diversify its energy mix by cutting its use of higher emitting liquid hydrocarbons for power generation, and build on the Company’s strategy to produce valuable feedstock for the petrochemical industry.

We are supporting the Kingdom’s Liquid Displacement Program, which aims to displace about 1 MMboed of liquids by sales gas, renewable deployment and efficiency improvements by 2030. Aramco’s Master Gas System Phase III Expansion (MGS III) facilitates this major program by expanding the gas supply capacity to the central and western regions, and extending the network to the southern region. In addition to supplying gas to utility plants, MGS III also extends the network to 11 industrial clusters in the Kingdom, enabling fuel switching, industrial growth, and lowering GHG emissions.

Renewable energy

The Kingdom’s utilities sector is positioned to undergo a major transformation driven by the Saudi Green Initiative (SGI), which aims to have 50% of the Kingdom’s power generation capacity from renewables, with the balance of 50% from gas. This policy has a multi-fold impact of more efficient power generation for gas compared to liquid burning, and significantly lower-GHG emissions.

Aramco has a pivotal role in facilitating this transition both through the Company’s gas expansion plans, and equity participation in Public Investment Fund’s (PIF) renewable projects.

The Saudi government has established a National Renewable Energy Program, in 2016, with the goal of increasing the generation capacity of renewable energy sources. Aramco supports the Kingdom on this journey as a part of a partnership with PIF in its renewable energy program.

Solar

In 2023, the 1.5 GW¹ Sudair solar plant, the first project developed by a consortium with PIF and ACWA Power, has received the full commercial operation certification from the power offtaker and the entire contracted capacity is now in full operation.

The consortium has achieved financial close of Al Shuaibah 1 and Al Shuaibah 2 solar PV projects with an aggregate capacity over 2.7 GW¹. The commercial operation for Al Shuaibah projects are expected to commence in 2025. Aramco plans to use the allocation of renewable energy certificates (RECs) from these investments. Aramco continues to assess other opportunities to advance its progress in renewable energy.

Geothermal

We are undertaking activities led by the exploration arm of the Company to evaluate the potential of geothermal energy in the Kingdom.

Three potential locations on the Western coast of Saudi Arabia have been identified and mapped using sophisticated subsurface technologies, and steps are underway to assess the extent of geothermal resources at each location. Alternative potential areas will be considered in the future to add to the Kingdom’s portfolio of alternative energy sources.



1. For solar energy projects: Sudair solar plant’s capacity 1.5 GW AC is equal to 1.8 GW DC; capacity of Al Shuaibah 1 and Al Shuaibah 2 solar PV projects is 2.7 GW AC, which is equivalent to 3.2 GW DC.

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Value chains and the materials transition

The materials transition

Reducing emissions in energy generation has been a core focus of climate mitigation efforts to date. However, another key lever to achieving a transition to lower emissions will be that of evolving how we use, produce and dispose of the materials which form the building blocks of the 21st century economy.

This “materials transition” will cover the entire product value chain, and will be critical to meeting surging demand for minerals, metals and materials projected to take place in the coming decades, driven by population and economic growth.

A viable materials transition will be key to unlocking an orderly energy transition by redefining the materials of modern life and mitigating emissions as the world’s energy demand grows.

On the production side, hydrocarbons will be increasingly be used without combustion, providing essential feedstocks to the innovative new materials needed in the energy transition.

For instance, each megawatt of installed solar and wind capacity currently utilizes around 8 to 10 tons of petrochemicals-based materials¹.

Further sustainability will then be achieved through a process of materials circularity, whereby materials and their emissions are recycled and reused both in products and in the form of alternative energy. One notable initiative that Aramco is pursuing in this regard is through the development of an advanced circular polymer through our affiliate, SABIC.

The materials transition creates significant challenges and opportunities, but among the latter is the chance for the chemicals industry to steadily supplement existing materials with more durable and sustainable alternatives, such as polymer- and emerging carbon-based materials.

These alternative materials can help to drive GHG emissions reductions across an array of industries which are reliant on traditional materials such as steel and concrete, including housing, construction, infrastructure and renewables.

To maximize this opportunity, Aramco believes that the chemicals industry must strengthen and accelerate its innovation efforts to continue developing more durable and sustainable materials, at scale, while reducing their cost; and, in the Kingdom of Saudi Arabia, that establishing an advanced materials center

could strengthen and complement existing programs and push the boundaries of innovation through global collaboration.

Material substitution has a high potential to reduce pressure on certain supply chains, given that alternative materials have the necessary properties to suit the given application.

Material substitution is likely to be driven by emission savings and also cost. Durable hydrocarbon-based materials can contribute to reduced carbon emissions compared to most metals.

Examples of material substitution include EV light weighting (reducing the weight of EV by substituting certain structural elements) which can alleviate pressure on battery value chains; and copper substitution with its’ conductive properties used in batteries, cables for grid, solar panels, etc.

Aramco is pursuing a number of initiatives along the value chain to drive this materials transition, leveraging our position as one of the world’s largest integrated energy and chemicals companies.



Award

Yanbu Refinery achieves recognition in the World Economic Forum Global Lighthouse Network

Aramco has received the World Economic Forum Global Lighthouse Network recognition under WEF’s Shaping the Future of Advanced Manufacturing and Production Platform. The award recognizes Aramco’s use of the latest 4IR technologies to help produce energy with lower emissions.

In 2023, Yanbu Refinery was Aramco’s fourth facility to be included, joining the Company’s Abqaiq oil processing and stabilization facility, Uthmaniyah Gas Plant, and Khurais Oil Complex. Yanbu Refinery is one of 21 new facilities added to the prestigious Network which now includes a total of 153 manufacturing facilities around the globe. We are the only international energy company globally to be represented by more than two facilities.

\$7 billion

invested in Shaheen in partnership with S-Oil – a significant step in our liquids-to-chemicals expansion

Liquids-to-chemicals

As part of the wider materials transition, petrochemicals are set to be the primary engine of oil demand growth in the coming years, and Aramco is investing heavily in this sector as we continue to diversify our portfolio into new, lower-emissions value chains.

In 2023, Aramco celebrated the groundbreaking of the \$7 billion Shaheen petrochemical project, in partnership with S-Oil, in South Korea. Shaheen is among Aramco’s biggest international downstream investments, representing a significant and sizeable step forward in our liquids-to-chemicals expansion. It is expected to be one of the largest integrated steam crackers in the world. It is also the first major commercial deployment of Aramco’s thermal crude-to-chemicals technology developed

in collaboration with Lummus Technology that aims to increase chemical yield with less energy intensity. In addition to this, we have continued to advance on our liquids-to-chemicals strategy in Asia, acquiring a 10% interest in Rongsheng Petrochemical in July 2023.

Nonmetallic deployment

Nonmetallic materials reduce carbon emissions by up to 60% compared to equivalent carbon steel solutions. They also promote in-Kingdom value by adding to local nonmetallic product manufacturers and service providers.

Our Unconventional Resources program was the first in the Kingdom to deploy the Reinforced Thermo Plastics (RTP) flowline in sweet gas services covering more than 1,000 km of RTP in flowlines and is deploying further increments; which will reach a total of 15,000 km of RTP lines across all areas of the Kingdom.



Sustainability in action

New materials for lower emission construction solutions

Engineered Cementitious Composites (ECC) are a special class of high-performance fiber-reinforced concrete with many potential uses, as ECC are more ductile than conventional concrete when applied in pavement, pipes, and structure.

Its use has many benefits, for example ECC pavement, for medium-traffic use, is anticipated to have up to 50% lower CO₂ emissions compared to conventional concrete pavement.

Aramco is collaborating with the University of Michigan, where the first demonstration of ECC materials as road pavement has been performed, and Aramco conducted a pilot demonstration in Dhahran as well.



1. Energy Intelligence Whitepaper: Building Blocks of the Energy Transition (October 2023)

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Investing in lower carbon emissions technologies and solutions

We believe that digital technologies can be a key enabler for Aramco and the energy industry's future by allowing the optimization of operations, and enhancing sustainability. With this in mind, Aramco has established a Digital Sustainability Flagship Program to streamline all the digital efforts across the Company related to climate and sustainability.

Strategic technologies being developed to enable emissions mitigation or displacement include renewables and energy storage, hydrogen production technologies, nonmetallic applications development, Thermal Crude-to-Chemicals deployment at our subsidiary S-Oil, lower-carbon fuels, engine technologies, as well as CCS, including stationary carbon capture and direct air capture.

63%

of total R&D spend was sustainability-related

In addition, as a member of the OGCI, we contribute financially to Climate Investment (CI), an independently managed, specialist investor. Its mission is to drive near-term GHG emissions mitigation through investment and market adoption of our portfolio company innovations across a network of investors and global partnerships. Over the past six years, it has built a portfolio of 36 companies with innovative products and services, operating in the energy, transportation, built environment, and industry sectors.

Research and development

In 2023, sustainability-related R&D was \$540 million, which equated to 63% of total 2023 R&D spend of \$861 million². Our R&D spend encompassed sustainability focused solutions to improve our business and energy efficiency, enhance company circularity, as well as supporting the global energy transition.

In 2023, 20% of the new patents filed were in sustainability technologies, an increase from 15% the year before.

Examples of ongoing R&D initiatives include:

- CO₂ mineralization to calcium and magnesium carbonates utilizing cement and steel waste materials;
- An initiative called PowerSense, which conserves and reduces energy by measuring the amount of electrical flow of each component at the rig;
- In-situ generation of hydrogen in subsurface formations; and
- Development of digital platforms to drive efficiency that can reduce Aramco's GHG emissions.

R&D focus areas	2023 spend (\$ million)	2022 spend (\$ million)
CCS	40.0	41.5
Renewable energy	7.5	6.4
Energy efficiency	71.0	64.8
Waste management and recycling	16.3	32.3
Water management	50.1	32.2
Gas treatment	42.8	40.5
Lower-carbon hydrogen production	57.8	26.4
Sustainable mobility	208.9	136.6
Crude-to-chemicals	16.4	30.3
Nonmetallic applications	29.6	24.2
Total R&D for sustainability technologies^{1,2}	540	435
Total Aramco R&D^{1,2}	861	737
% of sustainability-related R&D out of Aramco R&D spend^{1,2}	63%	59%

1. Includes direct R&D program costs plus estimated overheads.

2. This figure includes Company in-Kingdom plus Global Research Centers, SASREF, Motiva, ATC, ASC, AOC and SAAC.



Carbon capture and storage

With our deep understanding of the subsurface, and utilizing advanced technologies, Aramco continues its journey to become one of the key players in the CCS industry. The Company has continued its efforts to avail CO₂ sequestration capacity, performing several assessments to identify and develop new potential CO₂ storage sinks. Throughout 2023, site screening activities and viability assessments continued with a view to identify potential storage sites through data acquisition programs, including 3D seismic activities.

Jubail CCS hub progress

Following the collection of all the required subsurface data, an advanced 255 million cell simulation model was constructed to drive further optimization in the development plans for the Jubail CCS hub project. Phase 1 of the CCS project aims for up to 9 MMtpa CO₂ by 2027 (from which up to 6 MMtpa will be supplied from Aramco and remaining 3 MMtpa from non-Aramco facilities), supporting the Kingdom's goal to sequester 44 MMtpa of CO₂ by 2035.

Natural climate solutions

Natural climate solutions continue to play a complementary role where emissions abatement is challenging. In line with our interim target to plant 300 million mangroves in-Kingdom by 2035, Aramco planted 6.5 million mangrove trees in-Kingdom in 2023, bringing its cumulative total to over 30 million. These trees have been planted since 1993 when the Company started mangroves plantation trials and experiments at Abu Ali Island. We also had an independent carbon stock assessment done on Saudi Arabia's mangrove plantation initiatives to quantify the carbon sequestered to date of its planted and existing mangroves. A third-party validated the total carbon stock of planted and existing mangroves of almost 445,000 tons of CO₂e.

The majority of mangroves (26.5 million) were planted over the last three years as part of our efforts to develop natural climate solutions as part of our GHG emissions mitigation program. As mangroves mature, they sequester increasingly higher amounts of CO₂, which projects a promising trajectory for CO₂ sequestration by Aramco's mangrove plantations over the coming decades. In 2022 and 2023, Aramco's mangrove plantations sequestered 11,800 and 27,500 tons of CO₂ respectively.

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Carbon offsets and carbon credits

Aramco supports the use of market mechanisms that address climate change and sustainable development as they offer a balance between driving emissions reductions and supporting economic growth. To be effective, they should cover all emitting sectors and all types of GHG emissions, recognize carbon intensity differentiation, equity, and revenue neutrality, as well as transferability of potential credits.

Aramco retired approximately 500,000 carbon credits in 2023, against a corporate emissions plan to use carbon markets to support the delivery of our 2035 and 2050 emissions mitigation ambition, while directing climate finance towards climate change mitigation solutions. The use of carbon offsets is an important part of

Aramco's net-zero planning as they enable mitigation of hard-to-abate emissions and allow us to accelerate emissions reduction action, particularly where alternatives, such as CCS, are not fully mature and scalable.

In 2023, Aramco developed its Internal Guidelines for Carbon Offsets and Crediting that commit to sourcing high integrity carbon credits. We aim to develop a portfolio approach that could include spot purchases, long-term offtake agreements, and equity investment in projects. Our guidelines seek to balance commercial decisions with optimizing the impact of offsetting. Carbon credits will be retired against corporate emissions, assets, bundled products, or sold to promote third party reductions.

500,000

carbon credits retired in 2023

Due to the absence of an internationally unified standard, we use existing, reputable frameworks and benchmarks to ensure offsets are high quality. These include the Integrity Council's Core Carbon Principles and CORSIA-eligible credits. We have also developed additional internal quality criteria that would allow us to contribute to the Kingdom's NDCs. We intend to invest in projects with diverse economic and social development benefits that promote broader sustainable development goals, such as access to clean and affordable energy, job creation, enhanced biodiversity and women empowerment.

Aramco continues to play a leading and enabling role in supporting the development of the Regional Voluntary Carbon Market Company in Saudi Arabia (RVCMC). We participated in RVCMC's second auction, the world's largest of its kind, with the auctioning of over 2 million CORSIA-eligible and Verra-registered carbon credits, of which one million were purchased by Aramco.

Aramco's Sustainability Fund

At Aramco, we invest in breakthrough technologies and startups to find solutions to complex climate challenges. As hydrocarbons remain a significant part of the world's energy supply, we believe investment should be proportionate to the challenges in ensuring a stable and inclusive energy transition. This is why in October 2022, we launched the \$1.5 billion Sustainability Fund through our global venture capital arm, Aramco Ventures.

During the year, Aramco Ventures invested in UK's OXCCU catalytic technology to convert hydrogen and carbon dioxide into sustainable aviation fuel, in addition to providing financing for Parallel Carbon, a company that uses renewable energy for hydrogen production.

Recently, we have allocated an additional \$4 billion to Aramco Ventures, increasing its total investment capabilities from \$3 billion to \$7 billion between 2024 and 2027.

During the year, Aramco Ventures was named as a Top 10 Climate Investor globally by Climate50¹ an annually published list that aims to recognize the world's top 50 most impactful climate investors, and as a 'Top 100 Innovator in the Energy Transition' by Reuters².

Top 10

Climate tech investor globally

The Sustainability Fund's portfolio includes 27 investments with a total committed amount of \$394 million. In 2023, the Sustainability Fund committed \$239 million and closed investments in 17 companies. This has facilitated innovation in areas like carbon capture, synthetic fuels, and building energy efficiency. The Sustainability Fund is among the largest sustainability focused venture capital funds in the industry.

1. Acknowledged as a leading Climate Tech investor (Climate50)
2. Top 100 Innovator in the Energy Transition by Reuters, 2024



Sustainability in action

Aramco's first verified carbon offset crude cargo

In 2023 we launched a strategic initiative for a pilot project to deliver Arabian Light crude oil with a product level carbon emissions intensity and an emissions management plan in line with PAS2060 –using a cradle-to-gate partial lifecycle assessment approach, as the first of its kind in the Middle East.

This first pilot shipment entailed the calculation of total carbon intensity of 6.39** kg CO₂e/boe of which the production and loading stages were 2.42** kg CO₂e/boe. Contributing to the lower carbon intensity of Aramco's pilot shipment were emissions reduction initiatives across relevant facilities and the use of offsets for residual emissions sourced from the Saudi-based RVCM of a certified renewable energy project in the MENA region. Third-party verification was conducted by Lloyds Register Quality Assurance (LRQA) and the corresponding Qualifying Explanatory Statement is available [online](#).

We believe an understanding of product level carbon emissions, alongside GHG emissions reduction initiatives and the optional use of offsets for residual GHG emissions, all third-party verified, can assist stakeholders make more informed decisions.

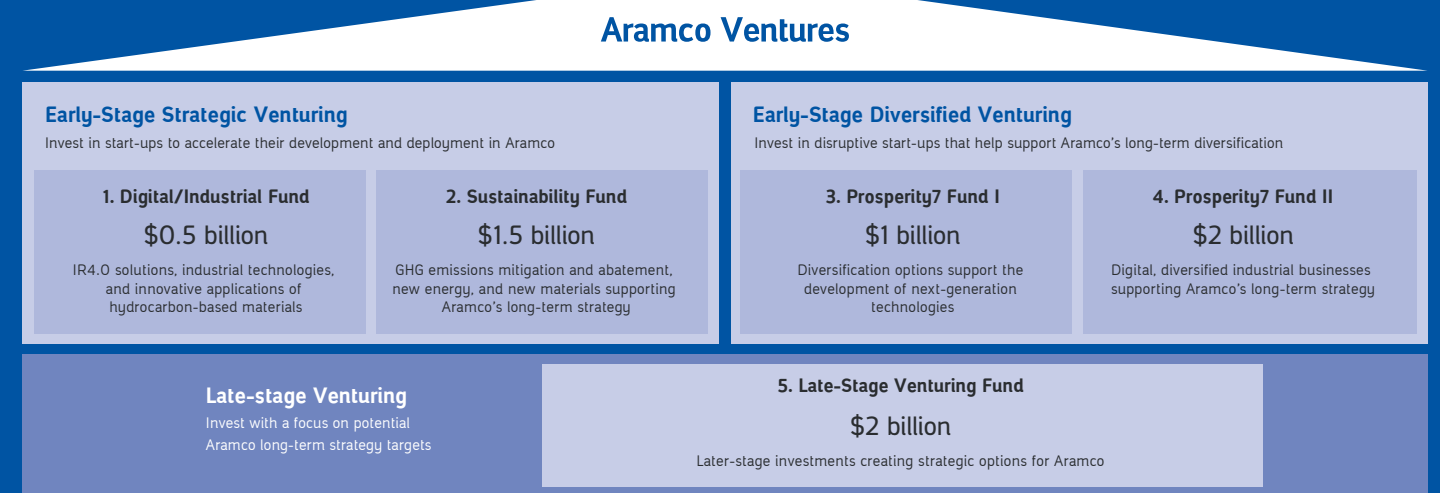
** This figure has undergone external limited assurance in accordance to the ISAE 3000 (revised). The assurance report can be found [online](#) on the Sustainability section of our website.

Spotlight on Aramco Ventures

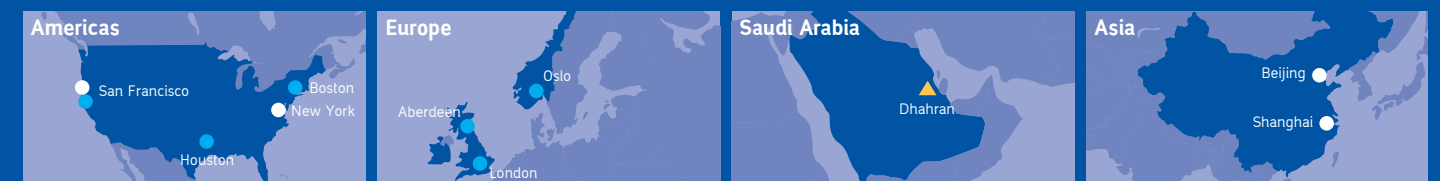
Impactful climate investing

Aramco Ventures manages five funds. These are a Digital/Industrial Fund investing in technologies of strategic importance to Aramco; the Prosperity7 Funds I and II investing in disruptive technology; the Sustainability Fund, which invests in start-ups with potential to support Aramco's climate ambitions and the Late Stage Venturing Fund supporting later stage investments. Aramco Ventures has offices in Saudi Arabia, the USA, Europe, and China.

Fund Structure
5 Funds under 3 Venturing Programs (\$7 billion)



● Strategic Venturing ● Prosperity7 ▲ Headquarters



Supporting the energy and materials transition through developing solutions and products

Lower-carbon Intensive Energy



Lower carbon aviation fuels

Aramco aims to be a provider of LCAF, which have lower carbon intensity compared to the global average for jet fuel and are compatible with existing fueling infrastructure. Aramco is working towards LCAF certification for its jet fuel production from some of its refineries as per the CORSIA requirements. LCAF aims to address the immediate challenges associated with scaling the production and deployment of Sustainable Aviation Fuels required to meet aviation industry targets.



Hydrogen

Hydrogen has a lower life-cycle carbon intensity than traditional fossil fuels and could help reduce emissions in hard-to-abate sectors such as heavy-duty transport and industrial applications. In October 2023, Aramco entered into an engineering agreement with Topsoe to construct a lower-carbon hydrogen production demonstration plant at the Shaybah Natural Gas Liquids (NGL) recovery site in Saudi Arabia. The demonstration plant will use renewable electricity in electrified steam reforming of hydrocarbons to produce hydrogen for use in power generation, with the resulting CO₂ being captured and sequestered.



Renewables

Aramco has ambitious plans to invest in 12 GW of solar and wind energy by 2030, and is also evaluating geothermal energy resources in Saudi Arabia. In efforts to advance renewables, Aramco has developed heat-tolerant flow batteries for storage, integration and efficient use of renewable power in hot environments (temperature over 55°C). Aramco is also developing cost-effective lightweight solar panels by replacing glass front-sheets with transparent polymer-based materials.



Natural gas

Natural gas is expected to serve as a bridging fuel in a transition to a lower GHG emissions future, and is displacing the burning of liquid fuels in the Kingdom. Aramco plans to increase its natural gas production by potentially more than 60% by 2030 compared to 2021 levels with a mix of conventional and unconventional gas. Aramco also made its first international investment in LNG by signing a definitive agreement in September 2023 to acquire a minority stake in MidOcean, an LNG investment vehicle owned by EIG, which is in the process of acquiring Australian LNG projects as part of an initial phase of acquisitions to create a diversified global LNG business.



Ammonia

Converting lower-carbon hydrogen to ammonia is a competitive solution for hydrogen transportation, given ammonia's high volumetric energy density, which makes it cheaper and safer to ship. Aramco has been helping to pioneer the development of a global supply network for ammonia. In April 2023, Aramco, FOC, SABIC AN, MOL, and JOE collaborated to ship the first independently-certified ammonia cargo to Japan for use in power generation. Aramco delivered two other shipments of accredited blue ammonia in 2023 through its affiliates ATC and SABIC Agri-Nutrients.

Carbon capture, utilization and storage



Direct Air Capture

In addition to developing technologies to capture carbon dioxide at the point of emissions, we are also researching and testing solutions to reduce the cost of capturing carbon dioxide directly from the atmosphere, via Direct Air Capture (DAC). Aramco is collaborating with Siemens Energy to develop a DAC test unit in Dhahran, Saudi Arabia. The test unit, which is expected to be completed in 2024, is intended to pave the way for a larger pilot plant. Captured carbon dioxide can be utilized as part of a circular carbon economy.



Carbon capture and storage hubs

If commercially scalable, CCS could be a key technology to enable the Company's emissions mitigation ambitions. Aramco is investing in world-scale CCS capabilities, and will continue development, drilling, and evaluation activities, to establish a wide portfolio of subsurface assets across the Kingdom. In partnership with Linde and SLB, Phase 1 of the Jubail CCS hub is expected to be one of the largest in the world with a capacity of 9 MMtpa. Aramco's share of CO₂ capture from its facilities is set to reach up to 6 MMtpa by 2027.



Mobile carbon capture

Aramco is striving to mitigate the emissions of the internal combustion engine, and our mobile carbon capture technology aims to achieve this by capturing CO₂ at the point of emission. Over the past decade, Aramco Transport Technologies R&D team has road-tested prototypes for an array of vehicles and trucks, generating more than a dozen granted patents and has licensed the technology to Daphne Technology for carbon capture in marine vessels.



CO₂ mineralization

Aramco is developing novel methods for permanently sequestering CO₂ through mineralization. We have demonstrated one such method through a pilot technology that stored up to 200 kg of CO₂ per ton of cement while curing precast concrete at a local plant. Additionally, Aramco and KAUST piloted a novel CO₂ sequestration solution using mineralization, which involves dissolving CO₂ in water and injecting it into volcanic rocks in Jazan, Saudi Arabia. The process permanently converts CO₂ into carbonate rocks.

Materials



Nonmetallics

The energy transition will rely in part on a concurrent materials transition, which will see a massive increase in demand for both existing and alternative materials. Aramco is a producer of nonmetallic materials for the oil and gas industry, and we are developing similar solutions for the automotive, construction, packaging, and renewable energy sectors. We are reducing the corrosion, weight, and cost associated with metals by replacing them with nonmetallic alternatives, such as carbon fiber and composites.



Liquids-to-chemicals

Aramco is creating and deploying technologies to produce highly demanded chemicals with less emissions. This is significant given that the chemical sector is one of the largest industrial energy consumers. One example is the Shaheen petrochemical project in South Korea, which represented the first major commercial deployment of Aramco's thermal crude-to-chemicals technology, developed in collaboration with Lummus Technology. We continued to advance on our liquids-to-chemicals strategy in Asia, acquiring a 10% interest in Rongsheng Petrochemical in July of 2023.