





Climate change and the energy transition

As one of the world's largest integrated energy and chemicals company, we have an important role to play to support energy security and promote sustainable practices in response to climate change.

The challenge is to develop and deploy technology solutions at speed and scale, to provide the benefits of oil and gas for future generations, while minimizing emissions. It is a complex, multidimensional, and capital intensive challenge that will span generations.

We are investing in technology needed for a stable energy transition that utilizes all sources of energy to meet the world's growing energy demand while reducing GHG emissions. Our focus is on leading in lower carbon intensity energy production and supporting the development of non-fuel applications for crude oil, targeting the highest impact solutions across our value chain.

Material topics

Climate change (including GHG emissions)

Relevant metrics

- Scope 1 emissions (million metric tonnes of CO₂e)
- Scope 2 emissions (million metric tonnes of CO₂e)
- Upstream carbon intensity (kg CO₂e/boe)
- Upstream methane emissions (metric tonnes of CH₄)
- Upstream methane intensity (%)
- Flaring intensity (scf/boe)
- Flared gas (MMscf)
- Energy intensity (thousand Btu/boe)

Relevant UN SDGs



For more details on relevant metrics, see page 86.



Learn more about Aramco's GHG emissions management program.

Scan here

Navigating the energy transition

Toward a low carbon system

Aramco supports the aims of the 2015 Paris Agreement to limit global temperature increase in this century to 2 degrees Celsius, while pursuing efforts to limit the increase even further to 1.5 degrees, and the commitment of the Kingdom of Saudi Arabia to achieve net zero emissions in its economy by 2060. This requires a transition of the global energy system toward a low carbon system, requiring thousands of large-scale projects across multiple sectors. This presents unprecedented design, engineering, and implementation challenges. The McKinsey Global Institute has estimated that a net zero world will cost around \$275 trillion by 2050¹.

Policymakers, industrial suppliers and customers recognize that this transition will not be uniform across geographies. What might be achievable today in more developed economies will be distinct from what is appropriate and effective in emerging markets. Growing markets, particularly in developing countries, face additional challenges to their ability to achieve sustainable development while meeting their needs for affordable, reliable energy. Reduction in GHG emissions across Europe and North America will proceed at a different pace from developing countries.

What does unite all economies and societies is not only the desire to address the impacts of climate change, but also the need for affordable, reliable energy. Across any society, higher energy prices are a burden that disproportionately impacts lower income households.

Balancing energy security, affordability and emissions

Events of the last few years, particularly COVID-19 and the conflict in Ukraine, have highlighted the risks of under-investment in energy sources and underlined the importance of energy security and energy access.

Alternatives to traditional hydrocarbon-based energy sources are progressing, but on their own will be insufficient to meet the world's energy demands today and ensure an orderly energy transition. As COP27 in Sharm El Sheikh highlighted, many developing economies depend upon the low-cost and reliability of hydrocarbons to avoid energy shortages and cost inflation — and they need realistic solutions now to ensure economic security, even while the energy transition develops in parallel.

Although global energy systems are becoming more efficient each year, requiring less energy to meet the same level of economic activity, the demands of a growing middle-class and facilitating access to economies and communities that lack access to energy is leading to a growing energy demand.

The definition of “affordable, reliable energy” diverges depending on the society and its position in the development index. Accordingly, prudent solutions will require a variety of energy sources and technologies. For example, around 800 million people do not have access to electricity and some 3 billion people still depend on indoor fires for cooking² — their requirements differ substantially from those living in a highly advanced economy.

With the focus on energy security and affordability, Aramco's continued investment and capital expenditure to increase supply, combined with our high level of reliability and low carbon intensity of production, will support a global orderly energy transition.

Our 2050 net zero ambition and 2035 GHG emissions reduction targets keep us focused on advancing in lower carbon intensity and abatement technologies and supporting the development of non-fuel applications for crude oil. We also continue to invest in the ability to meet the world's need for energy sourced from hydrocarbons. This includes expanding the gas supply in Saudi Arabia, and exploring new markets, including for blue hydrogen and additional non-combustible uses for oil.

A parallel materials transition

At the same time, the global economy is facing the realities of having to invest in new supply chains for minerals, metals, and materials. Without adequate investment in oil and gas, there remains the risk of raising the cost of the critical inputs needed for any transition.

Hydrocarbons will increasingly be used without combustion or where carbon emissions can be captured and removed. Fuels, such as blue hydrogen, using CCS technologies, are projected to increase in demand. Petrochemicals will provide feedstock essential to the development of new materials that will play a significant role in the energy transition — advanced, durable materials are essential for manufacturing wind turbines, solar panels, all modes of transportation,

McKinsey Global Institute has estimated that a net zero world will cost around

\$275 trillion by 2050¹

1. McKinsey Report: “The Net Zero Transition”, January 2022.

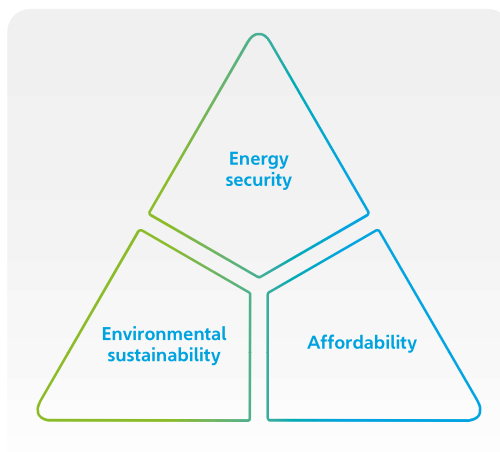
2. Overseas Development Institute: [‘Oil and gas, poverty and energy access’](#).

storage devices, and infrastructure. The faster we accelerate the transition, the more of these materials we will need. Today, chemical products made from oil and gas enable over 90% of all manufactured goods.

Energy transition scenarios

Scenario planning has been integral to Aramco's decision-making process for around a decade. The first scenarios were developed in 2014, depicting four pathways to the future energy landscape our business operates in. We have updated the scenarios five times since the start of this journey, each time successively incorporating the increasingly complex nature of our business amid a fast-paced transition. During this decade, the energy world has endured a major downturn in oil price cycles, a pandemic, and several geopolitical events. Scenarios and outlooks have been critically important to strategic dialogues within our Company.

The Company employs in-house expert economists and analysts to develop these scenarios. A wide range of internal and external stakeholders are engaged to determine the drivers of future energy landscapes, our strategies, and investment decisions. These and other important determinants, such as policy developments and climate goals, and technological progress form the basis of our scenario pathways.



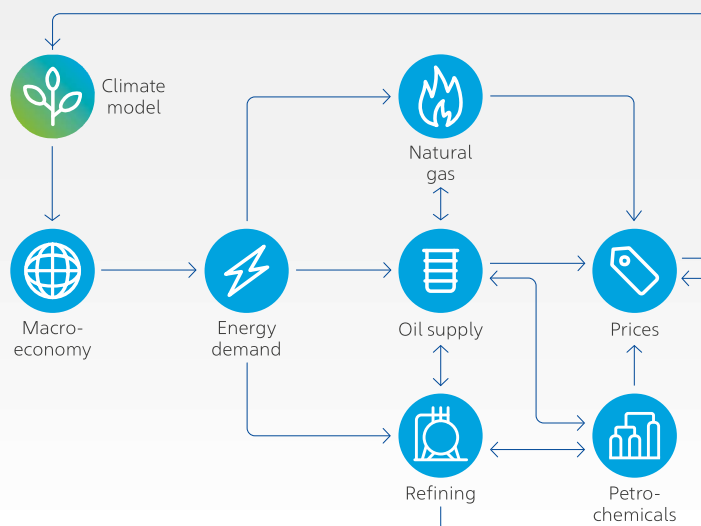
Once the scenario pathways are defined, they are modeled using a proprietary energy analytics system. Scenario outputs include global economic indicators, energy market fundamentals, and GHG emission projections.

In our latest set of scenarios, we have used the energy trilemma framework, first developed by the World Energy Council, to determine alternate pathways for the future. The framework utilizes affordability, energy security and environmental sustainability as three policy objectives that require balance and trade-offs. Each of our scenarios accentuates one dimension of the energy trilemma triangle, while a fourth scenario depicts a balanced approach to these trade-offs.

Aramco's integrated energy and economic modeling system

Aramco developed its proprietary energy solutions platform in collaboration with a number of industry-leading energy data providers and modelers. The platform is a computer-based integrated solution comprised of global economic and energy models. These models represent energy supply (oil, gas, and coal), demand (transportation, residential, commercial, and industrial), conversion (refining, power, and petrochemicals), and macroeconomics.

The system operates in an integrated manner with eight different sub-modules including economics, energy demand, climate, oil supply, gas supply, coal supply, refining, and petrochemicals. The system is capable of modeling at a country-level on 26 sub-sectors, 25 fuel types, energy carriers including electricity and hydrogen, and GHG emissions.



Our climate change and energy transition framework

Our corporate strategy is based on producing hydrocarbons that have one of the lowest upstream production costs and carbon intensities in the world, and supporting a global orderly energy transition towards a lower carbon emissions future through investing in technologies and offering lower carbon products, including e-fuels.

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

We have four areas of focus that provide the framework for our climate change initiatives and investments:

Differentiate

Leading in low carbon intensity operations

GHG emissions management

Flaring and methane reduction

Energy management

In-Company renewables

Sustain

Supporting the transition to low-impact energy pathways

Lower carbon fuels and transport technologies

Hydrogen

Diversify

Developing and growing low-impact value chains

Non-metallics

Liquids-to-chemicals

Renewable energy investment

Enable

Collaboration with partners to develop and deploy technologies and infrastructure at speed and scale

Carbon capture and storage

Leveraging technology

Developing offsets and supporting carbon markets



Read about how Aramco seeks to adopt the principles of the [circular carbon economy](#).

Scan here

Leading in low carbon intensity operations

GHG emissions management

We recognize the need to reduce our GHG and methane emissions and have ambitions and targets to reduce carbon emissions associated with our operations.

Our emissions reduction strategy includes investing in low-emission technologies, including CCS, energy efficiency programs and energy mix diversification. We are committed to developing and deploying innovative solutions, optimizing operations, and adopting efficient project designs.

Aramco's industry leading low carbon intensity production performance is the result of almost half a century of careful reservoir management and investment in efficiency, reducing flaring and produced water management. This has yielded an environmental advantage that forms a key pillar of our corporate strategy. We are confident that we can help the world meet its rising energy needs, while reducing emissions from our operations.

Net zero ambition

Aramco's ambition is to reduce GHG emissions from our operations and achieve a net zero GHG emissions footprint by 2050 across our wholly-owned operated assets.

Having undertaken analysis to support this corporate ambition, we know that achieving net zero operational emissions while we grow our business to meet global energy demand will be a huge challenge.

It requires internal targets to be set for our businesses and assets, and for these targets to be embedded into our business planning, to ensure capital expenditure and resource requirements are in place.

What are we doing?

Climate change risk and mitigation

Climate change is considered 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 reduction initiatives.

Risk	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 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, CCUS and CCS technologies, e.g., Jubail CCS Hub
Market: Loss of demand for hydrocarbons as customers move to achieve their GHG targets	<ul style="list-style-type: none"> Diversification into low GHG emitting products, e.g., chemicals and hydrogen
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

What are we doing?

Emissions management starts at the subsurface

Our philosophy of sustainable reservoir management is key in reducing our upstream carbon intensity. Instead of maximizing production from wells which could irreversibly damage them, we prioritize the long-term health of our reservoirs. This entails producing our fields at low depletion rates to prevent premature water breakthrough, reducing the quantity of produced water.

Using advanced reservoir modeling and real-time data, our geoscientists and engineers steer multilateral wells with maximum reservoir contact to ensure optimum well placement which help minimize water production. Additionally, these wells are equipped with smart completions which enable shutting off when detecting water. Such practices result in superior produced water management and low water oil ratios (WOR).

When the production of water is minimized, less energy is required for fluid separation, treatment and disposal. These energy savings result in lower carbon emissions. As a consequence, Aramco's average WOR is significantly lower than the global average, and hence our upstream carbon intensity is amongst the lowest globally.

GHG emissions targets

In parallel with our intensity targets, we are aiming to reduce our net annual Scope 1 and Scope 2 GHG emissions from both the upstream and downstream businesses by 52 MMtCO₂e from our business as usual 2035 forecast emissions.

By 2035, consistent with the corporate growth strategy in oil and gas production and development of new businesses, particularly hydrogen and liquids-to-chemicals, we forecast our business as usual Scope 1 and Scope 2 GHG emissions for our wholly-owned operated assets will increase to 119 MMtCO₂e. Our goal is to mitigate this growth in emissions and reduce our emissions to 67 MMtCO₂e by 2035.

Scope 1 and Scope 2 emissions upstream intensity: 15% reduction by 2035

(kg CO₂e/boe)

-15%



Scope 1 and Scope 2 emissions GHG reduction targeted by 2035

(MMtCO₂e)

-52



What are we doing?

Digital twins

Our EXPEC Computer Center developed a solution to reduce energy intensity and emissions associated with operating subsurface artificial lift systems, leveraging digital twin technology by optimizing the performance of our electric submersible pumps (ESP).

The system was trial tested across 42 ESP lifted wells resulting in a 22% average reduction in power consumption, equivalent to 12 GWh of energy savings during 2022. It is projected that deploying this solution across all fields will result in a 25% average reduction in artificial lift energy intensity at Company level.

During 2022, we have made progress toward achieving our 2035 and 2050 ambitions across our five identified levers: energy efficiency, reduced methane and flaring; increased renewables; CCS; and offsets to address emissions we cannot reduce or capture. For more information on our 2022 efforts and impact, please refer to pages 26 and 27.

We have also been conducting site-level bottom-up assessments of what it would take to decarbonize our assets. Once this is completed in 2023, we will update our decarbonization strategy in the next report.

GHG emissions

The Company's GHG emissions management program monitors direct (Scope 1) and indirect (Scope 2) emissions from wholly-owned operated assets, in a manner consistent with the GHG Protocol. Despite increased hydrocarbon production by 10% in 2022, total emissions (Scope 1 emissions and Scope 2 emissions) from the Company and its operationally controlled entities increased by only 6% (71.8 MMtCO₂e in 2022 versus 67.8 MMtCO₂e in 2021) compared to the previous year.

This was enabled by more efficient operations and a reduction in flaring intensity by 17% compared to the previous year due to improved operations of the Company's in-house flare gas recovery systems across several facilities. For more information on our flaring, please refer to page 28.

Our Southern Area Oil Operations won a 2022 Society of Petroleum Engineers Regional Distinguished Corporate Support Award for reducing its emissions by

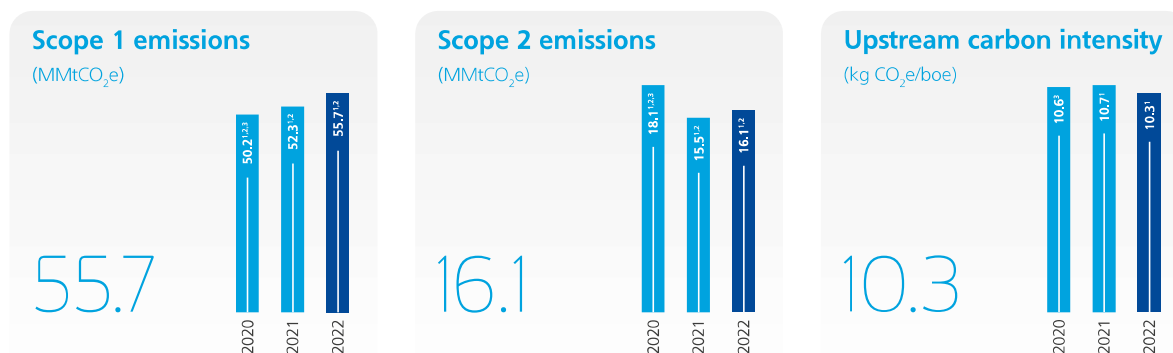
600,000
tCO₂e

What are we doing?

Targeted GHG reduction

Our Yanbu' Refinery facility successfully obtained the International Sustainability and Carbon Certification under its circular cracker oil initiative. The initiative drives the certification relates to an in-house sustainable circular route to produce circular cracker oil from waste oil to reduce our Scope 2 GHG carbon footprint.

1. 2018 was the first year our GHG inventory was independently assured.
2. This figure has undergone external limited assurance in accordance to the ISAE 3000 (revised). The assurance report can be found [online here](#).



Upstream carbon intensity

The Company's 2022 upstream carbon intensity figure remains among the lowest in the industry at 10.3¹ kg CO₂e/boe (2021: 10.7¹ kg CO₂e/boe).

This improvement is predominantly driven by energy efficiency, and reduced flaring across Upstream operations due to improved reliability and performance of our flare gas recovery systems (FGRS). In 2022, two new FGRS became operational in both Abu Ali and Qatif central processing facility resulting in estimated annual flared gas recovery of over 1.0 bscf per year.

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.

For more details on what we have done during 2022 regarding our progress on our five levers to meet our 2035 interim GHG targets, please refer to pages 26-27.

Scope 3 — value chain emissions

Our focus is on measurement, reporting, and management of those emissions within our direct control. To date, we have not reported Scope 3 emissions from our supply chain or from customers' use of our products. We are working on supporting the global energy transition towards a lower carbon emissions future through investing in technologies and working with suppliers to integrate ESG performance measures through our iktva program.

Our investment in hydrogen, chemicals and renewable energy sources and the increasing share of gas in our production provide products that will support the global energy transition towards a lower carbon emissions future. We continue to invest in a number of product stewardship partnerships and technologies to reduce emissions, this includes research and development into low emissions transport solutions.

During 2022, we increased our R&D spend on developing potential solutions that will assist the global energy transition towards a lower carbon emissions future — notably over a 45% increase in sustainable mobility R&D spend and over 380% increase in crude to chemicals R&D spend, reflecting the increasing importance of these areas to our future business. For more details on our R&D spend, please refer to pages 40-41.

What are we doing?

Vessel Speed Program

To support the national and corporate GHG reduction aspirations, our terminals instituted the Vessel Speed Program reducing the speed of vessels sailing through the Ras Tanura and Ju'aymah Port to 12 knots from 15 knots. 12 knots was determined as the optimal speed based on vessel engine efficiency, while minimizing impact on customers' satisfaction or our reliability. It is estimated that the program has reduced the GHG emissions of visiting ships by more than 90,000 tCO₂e per year⁴.

1. This figure has undergone external limited assurance in accordance to the ISAE 3000 (revised). The assurance report can be found [online here](#).

2. The Jazan Refinery (our downstream refinery) is excluded from our current GHG reporting because in 2022, it remains in the startup and stabilization phase and is not fully operational. Aramco is working to stabilize the refinery's operations and complete all necessary reporting configurations before the end of 2023. Reporting on the refinery's environmental and sustainability elements will commence immediately thereafter, in line with the Company's commitment to operational transparency.

3. Fadhili Gas Plant is excluded from 2020 GHG emissions inventory.

4. These emission reductions were calculated from real vessel performance data at different speeds and application of the International Maritime Organization guidelines. Prior to implementation, terminals benchmarked the initiative with other worldwide ports, such as Los Angeles and San Diego in the United States, and other countries including Canada and Singapore.

GHG reduction initiatives to 2035

Levers to achieve interim targets

To achieve reductions in GHG 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.

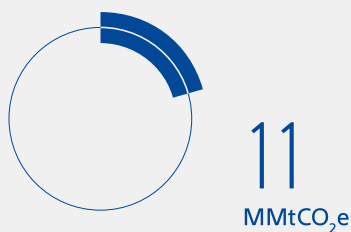
Energy efficiency

Our plans

- Continue to sustain/improve energy intensity
- Optimize co-generation and steam systems
- Ensure energy efficiency in new project design
- Expand utilization and application of the energy efficiency digital solutions
- Initiatives include gas turbine upgrades, boiler and fired heater efficiency improvements

Our actions in 2022

- Achieving a 3% improvement in energy intensity performance compared to last year
- Implementation of new energy efficiency technologies in our industrial and non-industrial facilities
- Using modern low NOx burner technologies to boost fuel efficiency
- Enhancing hydrogen blending capabilities for current boilers
- Upgrading and optimizing operation of boilers, steam traps, and fired heaters
- 36 organizations received the ISO 50001 certification for their energy management system
- Introducing new strategies for implementing energy conservation initiatives for more than 700 buildings



Flaring and methane

Our plans

- Commitment to OGCI near zero upstream methane intensity by 2030 and the World Bank's "Zero Routine Flaring by 2030" initiative
- Further enhance LDAR (Leak Detection and Repair) Program
- Unmanned aerial vehicles and satellite methane detection

Our actions in 2022

- Achieved our lowest ever flaring intensity
- Upstream methane intensity of 0.05%
- Implementing a Flaring Minimization Roadmap, with site-specific priorities across Aramco operations
- Investing in and developing innovative flaring reduction technologies
- Introducing a smart flaring monitoring system
- Installing high efficiency burners
- As part of the LDAR program, surveyed thousands of points across our operations in the Kingdom to minimize methane leaks
- Installed two new Flare Gas Recovery Systems at Abu Ali and Qatif Central Processing Facility



GHG reductions targeted by 2035



1. This figure may not match up due to rounding.

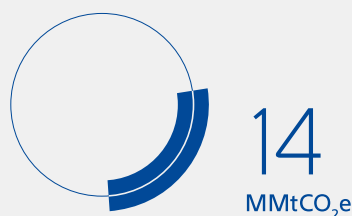
Renewables

Our plans

- Commitment to invest in 12 GW of solar and wind energy by 2030 for our business and also in support of the Kingdom's National Renewable Program

Our actions in 2022

- Sudair Solar PV Plant has reached 56% completion — power generation expected to start in Q4, 2024
- Approved installation of renewable systems to power 20 offshore water injection wells at Berri and Zuluf
- Installing PV systems to power Aramco's remote pipelines load



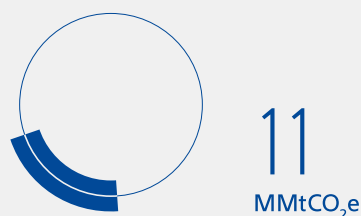
CCS

Our plans

- Jubail CCS hub to capture up to 11 MMtpa by 2035 — contributing towards the Kingdom reaching its goal of 44 MMtpa of CCUS by 2035
- Jubail Hub targeted to store 9 MMtpa, with Phase 1 capturing around 6 MMtpa by 2027 from gas plants at Wasit, Fadhili and Khursaniyah, plus circa 3 MMtpa from other industry sources
- Phase 2 will capture around 5 MMtpa and may include CO₂ from other facilities

Our actions in 2022

- Joint Agreement signed with SLB and Linde to build the Jubail CCS hub
- Identified 9 MMtpa of storage capacity with CO₂ injection expected by 2027
- Captured around 238 MtCO₂ from our pilot Hawiyah Natural Gas Plant resulting in a cumulative total of about 1,570 MtCO₂ stored in the reservoir, since the CO₂ injection started in 2015



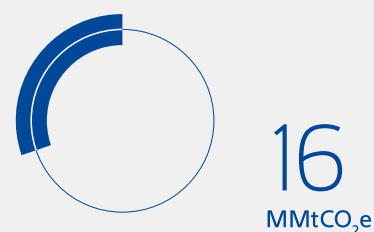
Offsets

Our plans

- Develop carbon offsets from natural climate solutions
- Ambition to plant 300 million mangroves in Saudi Arabia and 350 million mangroves outside the Kingdom by 2035 — expected to remove and offset an estimated 16 MMtCO₂e by 2035
- Assist in developing a credible and functioning carbon credit market in the Kingdom for carbon offsets and credits produced in the MENA region

Our actions in 2022

- Participated, and purchased credits, in the first carbon credit auction held in 2022 through the Regional Voluntary Carbon Market in Saudi Arabia



Flaring and methane

Flaring of waste gases has long been recognized as one of the most significant contributors to GHG emissions in the oil and gas sector. Aramco has been a pioneer in gas flaring reduction and now has industry-leading methane intensity and gas flaring metrics.

Minimizing flaring

Aramco is a signatory to the World Bank’s “Zero Routine Flaring by 2030” initiative and is committed to sharing best practices with industry partners to accelerate global flaring reduction.

During 2022, our flaring intensity fell by 17%, (4.60¹ scf/boe in 2022 versus 5.51 scf/boe in 2021) due to significant investments, installations and improved operations of our in-house flare gas recovery systems across several facilities and a reduction in routine and non-routine flaring. From April 2022, two new FGRS became fully operational in both Abu Ali and Qatif central processing facility, which will result in an expected annual reduction of 1.5 bscf per year.

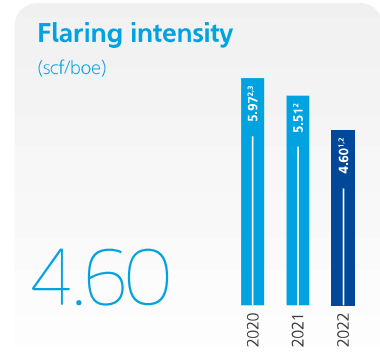
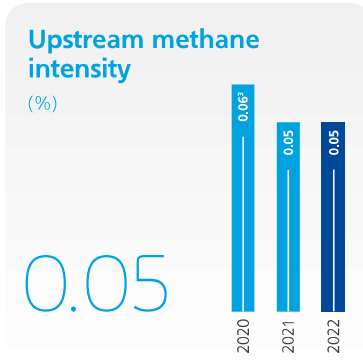
Substantial investments and developments in innovative flaring reduction technologies continued throughout 2022. These included implementing the Flaring Minimization Roadmap, which has identified priorities across Aramco operations, with every operating facility having a flare minimization plan and targets.

Aramco’s operations are monitored in real-time at our Fourth Industrial Revolution (4IR) Center in Dhahran. This has enabled us to achieve near zero routine flaring already. We have maintained a flare volume of < 1% of total raw gas production since 2012.

Methane

Addressing methane emissions is one of the fastest, most effective ways to slow the rate of global temperature rise.

An enhanced Leak Detection and Repair program for the Company’s methane emissions in the Kingdom prioritizes actions at operating facilities. Hundreds of thousands of points are surveyed across our operations to minimize potential methane leaks. We use drones to monitor and measure methane emissions from our operating facilities.



In addition to LDAR, we are assessing and deploying remote detection solutions and technologies such as the use of satellite monitoring.

Aramco’s upstream methane intensity measures the ratio of our upstream methane emissions for operated assets against the quantity of marketed natural gas. Our upstream methane intensity remained low in 2022 at 0.05% (0.05% in 2021) and is already well below the OGCI ambition to achieve at least 0.20% by 2025.

We have maintained a flare volume of

< 1%

of total raw gas production since 2012

What are we doing?

Two technologies

In 2022, two technologies were piloted to enhance the management of flaring emissions:

- A flaring monitoring system detects flaring performance and optimizes burner feed inputs via cameras equipped with artificial intelligence programs.
- We piloted portable ignition systems for on-demand flaring needs, replacing continuous flaring and emissions.

1. This figure has undergone external limited assurance in accordance to the ISAE 3000 (revised). The assurance report can be found [online here](#).

2. The Jazan Refinery (our downstream refinery) is excluded from our current GHG reporting because in 2022, it remains in the startup and stabilization phase and is not fully operational. Aramco is working to stabilize the refinery’s operations and complete all necessary reporting configurations before the end of 2023. Reporting on the refinery’s environmental and sustainability elements will commence immediately thereafter, in line with the Company’s commitment to operational transparency.

3. Fadhili Gas Plant is excluded from our 2020 reporting.

Energy management

Co-generation

Highly efficient co-generation plants enable us to produce electricity as a byproduct of our operations and are enabling self-sufficiency in electrical power generation for our own operating plants. We are retrofitting some of our existing plants with co-generation systems to create energy, as well as heat for oil and gas production processes.

We analyze the real-time data of the power generated, which allows us to streamline our carbon footprint.

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 2022, we achieved an average thermal efficiency of 70.7% (70.8% in 2021) in our interconnected co-generation facilities.

Energy efficiency

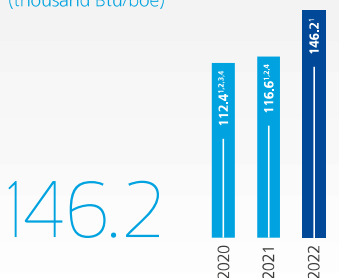
The Company seeks to reduce energy consumption at facilities, design new facilities to be energy efficient, and promote energy efficiency in Saudi Arabia.

While our reporting boundary has expanded as per footnote 1 below, in 2022, at a Company in-Kingdom level, the energy intensity was 112.9 thousand Btu/boe (a fall of 3% from prior year), which demonstrates continued improvement in our energy efficiency initiatives across our business.

We started an energy efficiency management program in 2000. The program has evolved through the implementation of energy efficiency initiatives such as process improvements, fuel gas optimization, higher co-generation utilization, continuous performance monitoring of significant energy users, reduction in energy for crude oil transportation, and load management of top energy users.

Energy intensity

(thousand Btu/boe)



As of 2022, we achieved an average thermal efficiency of

70.7%

in our interconnected co-generation facilities

Several initiatives have been planned to improve energy efficiency, including:

- Upgrading of simple cycle gas turbines with energy efficient combined cycle systems;
- Replacement of older inefficient boilers with highly efficient fast ramp up boilers; and
- Implementation of advanced digital solutions to improve energy efficiency performance.

At the end of 2022, all our operational facilities have received the ISO 50001 certification for their energy management system (EnMS). EnMS enables our facilities to focus on an ongoing, sustained improvement in energy efficiency, and reduction in greenhouse gas emissions, along with monetary savings as a result of smarter energy utilization and improved energy efficiency.

What are we doing?

Innovative Energy Project of the Year Award

Aramco won the Innovative Energy Project of the Year Award from the Association of Energy Engineers in recognition of implementing the Energy Demand Forecasting Solution in Oil and Gas facilities. The solution was recognized due to its novel machine learning capabilities that accurately forecast energy demand.

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 and 2020 figures are at a Company in-Kingdom level only. In 2022, at a Company in-Kingdom level, the energy intensity was 112.9 thousand Btu/boe.

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Pathways to lower carbon energy

Aramco’s strategy is to increase its production of hydrocarbons while seeking to maximize opportunities for lower carbon products.

We recognize the need to reduce emissions and support a global orderly energy transition towards a lower carbon emissions future through investing in technologies and offering lower carbon products, such as e-fuels, and working with suppliers, to integrate ESG performance measures through our iktva program.

Low carbon fuels and transport technologies

Achieving sustainable mobility requires collaboration across the value chain to meet consumer demand for affordable, low emission transport. Electric vehicles are fast growing and will play an important role in mitigating climate change when integrated with renewable electricity. However, in the near term, transport electrification alone is unlikely to be adequate to meet global CO₂ mitigation goals. This has to be complemented by advanced combustion engines, fuel cell vehicles, and low carbon fuels, including renewable fuels and hydrogen.

Sustainable mobility

Aramco has around 100 scientists and engineers in four locations across the world working on the challenges of sustainable mobility. Through our global network, we are working to create breakthrough transportation technologies with the goal of improving efficiency that has the potential to reduce emissions — both CO₂ and other air pollutants, including NOx and particulates.

We are seeking to redesign internal combustion engines, and the fuels that power them including advanced combustion systems, novel engine architectures, and innovative after treatment systems.

We have two flagship projects that aim to advance the development of low carbon synthetic fuels, one in Spain and another in Saudi Arabia. Aramco’s low carbon synthetic fuels plan is to combine CO₂ captured from industrial processes or directly from the air with green hydrogen and target a CO₂ reduction potential of at least 80% on a lifecycle basis.

We are researching:

Gasoline compression ignition

Opposed piston engines

Turbulent jet ignition

Dilute boost engines



For more information on advanced engine technologies see our [website](#)



Scan here

What are we doing?

Demonstrating sustainable fuels through Formula racing

Building on our strategic partnership with Formula 1 (F1) to accelerate our engineering excellence and achieve our respective net zero targets, we are working closely with F1 to support their goal of fully switching to sustainable fuels by 2026.

In February 2022, Aramco entered into a strategic partnership with the Aston Martin Aramco Cognizant Formula One™ Team to promote the development of highly efficient internal combustion engines to accelerate high performance sustainable fuels and advanced lubricants, making use of the diverse technologies Aramco has developed.

Beyond F1, Aramco signed a Memorandum of Understanding with Formula Motorsport Limited to introduce alternative, lower carbon fuels in the Formula 2 and Formula 3 racing championships beginning in 2023.

Through this collaboration, we plan to demonstrate the potential of liquid synthetic fuels to reduce emissions both in motorsport and the broader transportation sector.



What are we doing?

Aramco Ventures and our \$1.5 billion Sustainability Fund

Aramco Ventures is our venture capital vehicle, that invests globally in innovative startup companies.

Aramco Ventures supports three key elements of Aramco's overall strategy:

- Commitment to innovation and technology leadership.
- Supporting our digitalization journey and use of Fourth Industrial Revolution (IR 4.0) technologies.
- Supporting the Company's sustainability ambitions and development of new lower carbon energy solutions.

As we accelerate the implementation of our vision to become the world's preeminent integrated energy and chemicals company, the breadth of our businesses, operations, and geographic presence offer unique opportunities to pilot and deploy the technologies created within the startup companies we invest in.

Launched in 2022, Aramco Ventures' new **\$1.5 billion Sustainability Fund** will accelerate the Company's progress towards developing and using innovative solutions to address the climate challenge, and represents a major expansion of our sustainability investment activities.

The Sustainability Fund's focus is on sectors closely aligned with Aramco's decarbonization and lower carbon energy solutions business strategies, including:

- Carbon capture, utilization and storage;
- Renewable energy and energy storage;
- Energy efficiency technologies;
- Nature-based solutions;
- Hydrogen and ammonia value chains;
- Synthetic renewable fuels, including direct air capture; and
- Digital sustainability solutions.



The Sustainability Fund builds on Aramco Ventures' existing strategic venturing program, which invests in companies developing technologies with strategic importance to Aramco to accelerate their development and deployment in Aramco's operations.

This fund has invested in various companies since inception, with three companies achieving IPO, six reaching "Unicorn" status, and more than 25 technologies deployed in Aramco. This fund will continue to operate focusing on digital and industrial technology domains.

Our **\$1.5 billion Sustainability Fund** will be among the largest sustainability focused venture capital programs announced globally, and the largest by any oil and gas producer.

It will join Aramco Ventures' other investment programs:

- As a founding member of the OGCI, Aramco participates in **OGCI's Climate Investments Fund**. This is a \$1 billion fund that includes the participation of 11 major oil and gas companies. It is focused on investments in carbon capture, utilization, and storage, methane emissions reduction, and carbon dioxide emissions reduction in the oil and gas and transport sectors.
- **Prosperity7**, Aramco's \$1 billion diversified growth venturing program invests in disruptive technologies and start-ups outside of the energy sector. The program focuses on investing in highly scalable start-ups in the U.S. and China. The program has made over 25 investments to date.

1. Unicorn companies are those that reach a valuation of \$1 billion without being listed on the stock market.

Hydrogen

Hydrogen is a primary element in oil and gas, and holds significant potential as a clean, affordable energy that could support emissions reductions in hard-to-decarbonize sectors such as heavy-duty transport, heating, and industrial applications. We believe hydrogen has significant potential to provide a material reduction in GHG emissions, as a global market develops over the next decade.

Hydrocarbon’s crucial role in the development of a global hydrogen business

Despite the interest and possibility of producing hydrogen from multiple energy sources, in the short and medium term, hydrocarbons will remain the primary feedstock for its production.

Hydrogen has the potential to become a tradeable commodity, which opens commercial opportunities for our business over the medium to long term.

At the same time, investments in low carbon hydrogen can help foster new technological and industrial development in economies around the world, while also creating skilled jobs.

Natural gas and hydrogen

Natural gas has the potential to be a viable, cost-effective feedstock for blue hydrogen production. Natural gas is the most used feedstock for hydrogen production today.

Aramco is a steering member of The Hydrogen Council, a CEO-led organization that promotes collaboration between governments, industry and investors to provide guidance on accelerating the deployment of hydrogen solutions globally.

What are we doing?

Blue hydrogen certification

In 2022, Aramco and the SABIC Agri-Nutrients Company obtained the world’s first independent certifications recognizing “blue” hydrogen and ammonia production.

The certification was granted by an independent testing, inspection and certification agency based in Germany, to SABIC AN, in Jubail, for 37,800 tonnes of blue ammonia and to Aramco’s wholly-owned refinery (SASREF), also in Jubail, for 8,075 tonnes of blue hydrogen.

To certify ammonia and hydrogen as “blue” a significant part of the CO₂ associated with the manufacturing process must be captured and utilized in downstream applications.

Capitalizing on this agreement, we made the world’s first commercial shipment of blue ammonia to South Korea.



Developing and growing lower environmental impact value chains

The energy transition offers challenges but also various opportunities for us to diversify our portfolio into new, lower impact value chains, including utilizing hydrocarbons for non-combustion uses, such as non-metallic materials and chemical applications, as well as investment in renewables projects.

Such actions provide us with commercial opportunities and help improve our resilience to changes in customer demands caused by the energy transition.

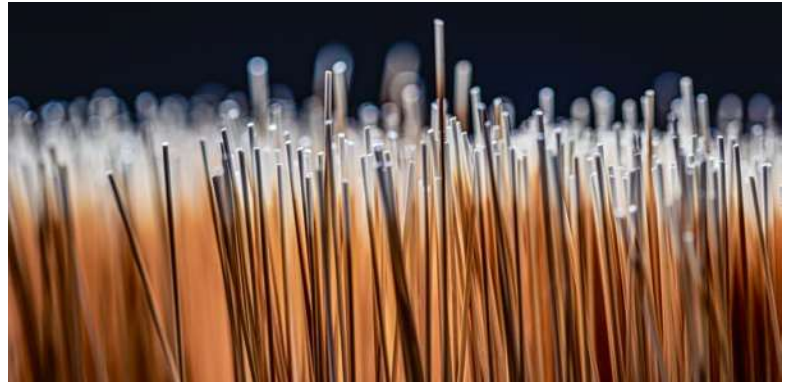
The materials transition

According to a report issued this year by the Atlantic Council, a net zero energy system will be six times as mineral intensive as its hydrocarbon-based predecessor. However, the supply chains needed to deliver these minerals are significantly underdeveloped and undercapitalized; there is a projected \$2 trillion investment gap over the next 15 years for the minerals needed to limit climate change — the world is underprepared for the risk of surging transition-related mineral demand. For example, one megawatt of installed renewable energy capacity utilizes eight to 11 tonnes of petrochemicals-based materials.

Energy demand is projected to more than double from 79 gigatonnes in 2011 to 167 gigatonnes in 2060. Materials production, use, and eventual disposal already accounts for almost a quarter of all global CO₂ emissions. The increase in materials use, even if decoupled from economic growth, will be accompanied by a further rise in CO₂ emissions, particularly in hard-to-abate industries.

For example, emissions from concrete are projected to total almost four gigatonnes of CO₂ by 2050 because of the growth in demand. Meanwhile, the iron and steel sector accounts for more emissions than the whole of road freight, and global demand for steel alone is expected to rise by more than a third by 2050.

To achieve an accelerated materials transition, cutting-edge R&D, innovation, and the necessary investments are essential.



At Aramco, we see opportunities arising from the materials transition. Steel, concrete and other traditional materials are responsible for significant CO₂ emissions. Non-metallic materials, (e.g. polymers) and other carbon-based materials, can provide durable materials at a lower GHG impact with potential use in housing, construction, infrastructure, automotive, and renewables. At Aramco, we are working across them all.

No matter which energy transition scenario plays out, oil demand from the petrochemicals sector is likely to remain robust. In fact, under a net zero scenario, petrochemicals could account for more than half of total global oil demand by 2050.

The more intense the transition, the more important petrochemicals will be to the oil and gas industry, and other industries. Our pursuit of sustainable materials is underpinned by a powerful business case that is driving our world leading chemicals growth ambitions — making our business portfolio even more robust.

There is a projected

\$2 trillion

investment gap over the next 15 years for the minerals needed to limit climate change

Liquids-to-chemicals

Our 2020 acquisition of a 70% stake in SABIC brought together two global companies committed to growth and value creation in petrochemicals.

This propels our strategy to convert up to 4 million barrels per day of liquids-to-chemicals. More advanced, more sustainable materials would strengthen the power of our net zero ambition and our chemicals’ strategies. To earn a larger share of the materials market in high volume applications, we must be cost and GHG competitive.

In 2022, we announced the first large-scale deployment of our crude to chemicals cracking technology at our S-Oil integrated downstream hub in Korea and a joint project between Aramco and SABIC to develop a crude-to-chemicals complex in Ras Al-Khair.

These are major steps forward in our downstream business, and show the power of technical innovations to meet our ambitions.

Conversion of crude oil into chemicals diverts our carbon from the transportation fuel value chain into durable goods.

Our chemicals business spans production of basic chemicals such as aromatics, olefins, and polyolefins to more complex products such as polyols, isocyanates, and synthetic rubber.

Our crude-to-chemicals technologies have the potential to deliver higher chemical yields. By converting crude oil directly to chemicals, we will optimize or eliminate several energy-intensive industrial processes, creating cost and operational efficiencies that result in high value chemical product streams.

What are we doing?

TC2C™ — Thermal Crude to Chemicals

The TC2C™ platform was designed by Aramco and its partners to produce greater than 70% chemicals from every barrel of crude oil, while maintaining top tier efficiency. To reduce CO₂ emissions while also improving profitability, TC2C™ deploys a simplification of the crude oil separation process, relative to a traditional fuels-directed refinery, thereby reducing energy and utility requirements. The reuse of heat from the steam cracking section reduces energy consumption even further.

The optimized integration of the hydroprocessing reactor platforms into a single high-pressure loop enables a significant reduction of equipment count compared to more traditional approaches. Furthermore, through careful management of high-value streams such as hydrogen, and by internally recycling low-value streams, production of waste from the process is minimized.

Such efficiencies in energy and material use are major factors in reducing the carbon footprint and capital expenditure of a TC2C™ facility.

TC2C™ was selected in 2022 for its first commercial deployment, as part of our S-Oil integrated downstream hub (Shaheen project) in South Korea.



For more information on our chemicals business, please refer to our [website](#)



Non-metallics

Non-metallics are materials such as plastics and other such applications, that can replace traditional materials and minerals. They can provide improved performance and lower maintenance costs and have potentially lower life cycle costs, with greater resistance to corrosion, and a lower carbon footprint than like-for-like alternatives.

In the oil and gas industry, plastics are already being used for various applications, such as in pipelines. In the future, carbon fiber reinforced plastics will be used to manufacture large diameter pipelines with greater strength and operating efficiency than legacy steel-based pipelines.

Today, the cost of advanced composite materials are becoming more competitive and we need to continue to invest in R&D in this sector — by finding new solutions and efficiencies, we can help drive the adoption of new materials at scale across the globe and thereby help meet net zero ambitions.

Renewable energy investments

Renewable energy, including power from solar and wind, is an energy source required under any energy transition scenario. With more than 320 sunny days per year and ample wind, Saudi Arabia's geography and climate hold great potential for harnessing these renewable energy sources. Deployment of renewable resources within the Kingdom will reduce GHG emissions and support long-term prosperity.

The Saudi government has established a National Renewable Program with the goal of increasing the generation capacity of renewable energy sources to over 58 GW by 2030. 40 GW is planned from solar, 16 GW from wind energy and the balance from other renewable energy sources.

Aramco is supporting the Kingdom on this journey and has committed to investing in 12 GW of solar and wind energy by 2030 by being part of a consortium led by ACWA Power to develop the 1.5 GW Sudair solar plant, a key project in Saudi Arabia's renewable energy push. We will use the allocation of renewable energy credits from these investment toward offsetting the emissions associated with power supplied to our operations.

Construction of the Sudair Plant has reached 56%. The project is expected to commence power generation in Q4, 2024.

What are we doing?

Microalgae

Aramco is exploring various applications for microalgae. The Arabian Peninsula is ideal for microalgae production with its extensive, unique *sabkha* (salt flat) formations along the Arabian Gulf.

Through the photosynthesis process, algae efficiently converts sunlight, CO₂, water, and the available nutrients in the wastewater into a carbohydrate and protein-rich biomass, and fresh oxygen, which is then released back into the atmosphere. The resulting biomass can then be converted into many useful products such as biofuel, animal feed, and pharmaceuticals.

Sabkhas can be easily converted to saline algae production ponds. *Sabkha* areas are in close proximity to many of Aramco's industrial facilities, meaning that emissions can be utilized to enrich algae ponds, increasing the potential for productivity and in turn reduce the Company's emissions.

Aramco also trialed an artificial carbon capture and algae production system, known as the "Clima Tree". This uses a microalgae photobioreactor integrated with a patented CO₂ scrubber to capture and store CO₂ in the form of a carbonate mineral, and produce algae biomass as a byproduct. The Clima Tree has been designed by Aramco in collaboration with Greengroves Environmental Services.

What are we doing?

NEXCEL — Non-metallic Excellence and Innovation Center

Aramco and the China Building Materials Academy (CBMA) launched NEXCEL, a new Non-metallic Excellence and Innovation Center, to further advance the use of non-metallic materials in the building and construction sector.

NEXCEL promotes the development and application of non-metallic technologies by exploring opportunities for joint projects in research and development, standards development and adoption, professional development and certifications, advocacy and international outreach.

NEXCEL joins the Aramco-launched NIC: Non-metallic Innovation Centre at The Welding Institute in Cambridge, U.K.; and NEX: A Center of Excellence for Non-metallic Building Materials at the American Concrete Institute, headquartered in Michigan, USA.

Collaboration with partners to develop and deploy technologies and infrastructure at speed and scale

Collaboration with partners to develop and deploy technologies and infrastructure at speed and scale is necessary to support emissions reductions and the development of low carbon business opportunities.

Working with other companies, including contractors, industry peers or companies in our product value chains, and with academia and research institutes, offers an opportunity to share learning and risk, and multiply the impact of investment.

Carbon capture and storage

CCS is identified as a major tool to achieve the global net zero emissions ambition. Industry and governments are responding to this.

In 2022, more than 60 new CCS facilities were announced globally (around a 40% increase in CCS capacity since last year) and resulting in the CCS capacity of all CCS facilities under development globally to 244 MMtCO₂ per annum¹.

We believe capturing and storing, and, where possible, reusing CO₂ has the potential to significantly reduce global emissions. Saudi Arabia has the know-how and scale to capture and store large amounts of CO₂, which could be reused and reutilized. It is an important part of the circular carbon economy and the central lever to support the decarbonization of our own business and operations. It is also an essential element of an integrated blue ammonia and hydrogen program. Partnerships will be required for the development of commercial solutions.

Aramco has set a goal of developing CCS capacity to capture up to 11 MMtCO₂ annually by 2035. The ability to grow our CCS capacity is critical to our efforts to decarbonize, and will be supported by government incentives that will help to develop the infrastructure that will be required.

What are we doing?

CO₂ nanobubbles

When CO₂ is captured in liquid form, CO₂ bubbles are formed. We are investigating CO₂ nanobubbles (CO₂ bubbles with diameters less than 200 nm) for near wellbore stimulation in conventional formations as they have the ability to sequester more CO₂ in the same reservoir than common larger sized CO₂ bubbles. CO₂ nanobubbles are also being considered for green energy applications, such as algal biocrude production.

For unconventional formations, carbon capture underground treatment and sequestration technology is being explored to chemically treat formations with the goal of increasing sequestration capacity.

In parallel, we are developing opportunities to use captured CO₂ for conversion into other materials or products with higher economic value and where either combustion is avoided or lower levels of CO₂ are emitted, e.g., plastics, concrete and biofuels.

CO₂ is a primary building block, which can be used both directly and as a feedstock. Current advanced CO₂ utilization takes place in chemicals production, mineralization processes, and plastics and polymer production. We are also exploring direct air capture — a less mature technology — with technology partners.

We realize the value that a decarbonization lever like CCS can achieve and as such we have fast-tracked the assessment and the development timeline for our first saline aquifer CO₂ CCS project. The assessment entailed the deployment of multiple rigs to drill evaluation wells, and simultaneously acquiring all relevant subsurface data, in order to expedite the technical evaluation of the saline aquifer sink.

This has led to the announcement of our world-scale CCS hub that will have the capacity to deliver 9 MMtpa of CO₂ by 2027 and sequester it in our saline aquifer sink.

1. [Global CCS Institute – Global Status of CCS 2022 Report.](#)

What are we doing?

Jubail carbon capture and storage hub

CCS is one of the key elements of the Saudi Green Initiative and a major contributor to the Kingdom's plan to achieve its 2060 net zero ambition.

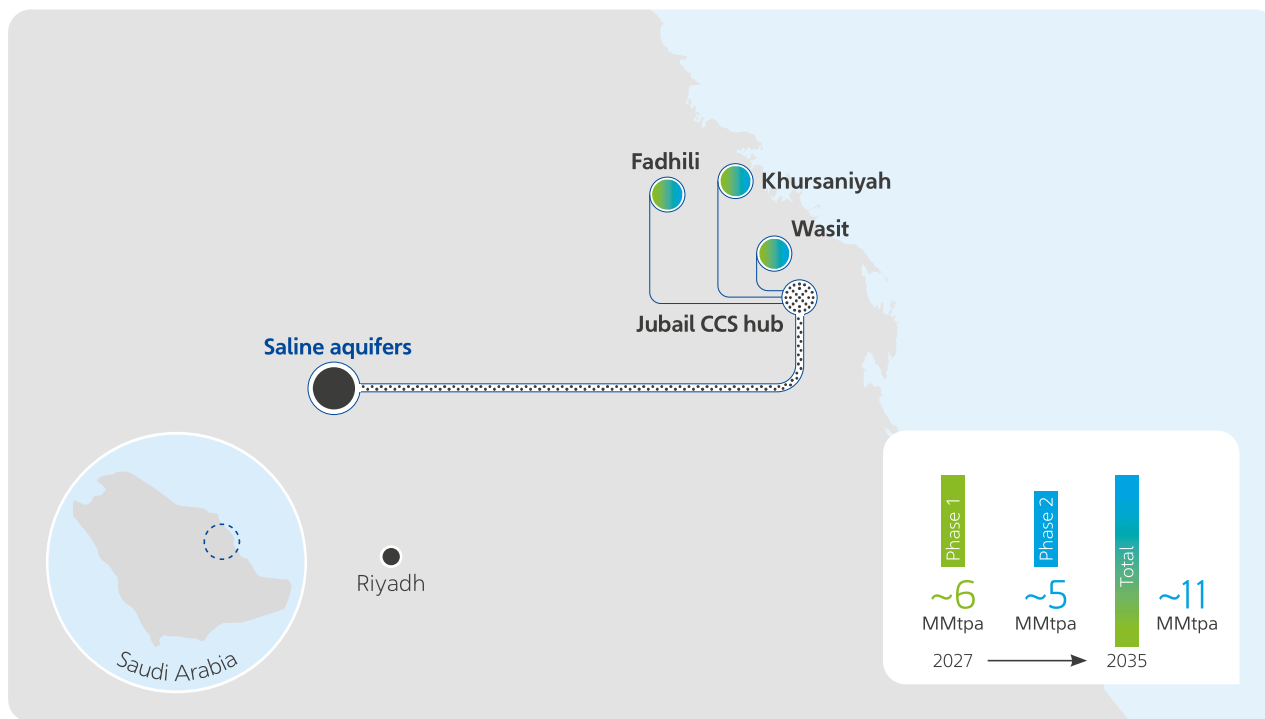
In November 2022, the Ministry of Energy announced a target of capturing 44 MMtpa of CO₂ by 2035. Aramco is a key partner supporting this ambition, and we signed a joint development agreement with SLB and Linde in building a CCS hub in the Jubail industrial zone in the Eastern Province of Saudi Arabia.

This project will be one of the largest CCS hubs globally, and plans to capture up to 9 MMtpa of CO₂ per year from 2027 onwards (Aramco's share is around 6 MMtpa and our partners' share is 3 MMtpa).

To execute the project, Aramco has signed a joint development agreement with experts in the field to design, develop and construct the CCS hub, with a planned completion date of 2027. Phase one of the CCS hub is intended to capture around 6 MMtpa CO₂ by 2027 from three Aramco gas plants (Fadhili, Khursaniyah, and Wasit). Phase 2 of the CCS hub is intended to capture around 5 MMtpa by 2035.

By 2035 up to 11 MMtpa of CO₂ will be captured from Aramco facilities and transported through a pipeline network via the Jubail CCS hub and stored below ground in saline aquifers.

Aramco's planned CCS facilities in Saudi Arabia



What are we doing?

Concrete and CO₂ capture

The manufacture of cement — the principal ingredient of concrete — produces around 7% of annual global GHG emissions.

If the global precast concrete industry implemented CO₂ curing technology, it is estimated it could recycle at least 63 million tonnes of CO₂ every year. The actual figure may potentially be as high as 246 million tonnes of CO₂.

At Aramco, we have developed a pilot program that has delivered storage of 150 to 200 kg of CO₂ in a tonne of cement in precast concrete, or 60 to 80 kg of CO₂ in 1 m³ of precast concrete, outside of the laboratory at a precast concrete plant. We achieved this by combining the CO₂ with steam.

Offsets and carbon credits

A carbon offset is a reduction in emissions of CO₂ or other GHGs made to compensate for emissions made elsewhere. A carbon credit is an instrument traded in carbon markets representing this reduction and may take alternative names such as allowance, permit, or reduction unit. Aramco seeks to generate carbon credits by undertaking greenhouse gas reduction projects.

The use of offsets is an important part of Aramco's net zero planning as they enable the mitigation of hard to abate emissions. They also allow us to accelerate emissions reduction action, particularly where alternatives, such as CCS, are not fully mature.

Carbon reduction operations may include a variety of techniques, such as natural climate solutions, or engineered carbon removal. Commercial arrangements can vary from directly financed projects and joint ventures, to fund investments, sustainable financing mechanisms in the form of carbon credits and direct purchases of carbon offsets from a voluntary carbon market.

While all these techniques help to generate carbon offsets, our goal is to diversify the carbon offsets portfolio, balancing the carbon footprint with the value of co-benefits for the communities and ecosystems where we operate.

Aramco has planted

24 million

mangroves along the Arabian Gulf and Red Sea coastlines and over 3 million terrestrial native trees — and we plan to plant millions more



Natural climate solutions

Natural climate solutions are conservation, restoration and improved land management actions that increase carbon storage or avoid GHG emissions in landscapes and wetlands across the globe. Combined with innovations in clean energy and other efforts to decarbonize the world's economies, natural climate solutions can deliver significant support to combating to climate change.

Aramco is exploring the use of natural climate solutions to generate offsets. To date, Aramco has planted 24 million mangroves along the Arabian Gulf and Red Sea coastlines and 3 million terrestrial native trees — and we plan to plant millions more. Mangroves and trees form a natural sink for CO₂.

Mangrove and native tree planting also restores natural habitats, encouraging biodiversity, and act as a natural barrier to coastal erosion.

To develop useable offsets, Aramco plans to develop baselines, confirm methodologies and establish third-party measurement and verification of carbon stored in mangroves and other trees being planted in Saudi Arabia and abroad.

Aramco is working with external experts to assess the baseline ecosystem carbon stock around our existing mangrove forests to support and facilitate current and future verification assessments of carbon offsets from natural climate solutions projects. A third-party assessment, using The Blue Carbon Initiative methodology¹, was undertaken to quantify the cumulative levels of carbon sequestered through mangroves planted by Aramco alongside both coasts of Saudi Arabia over a number of decades. The assessment recorded an average carbon stock of around 340,000 tCO₂e (between 276,000 tCO₂e and 410,000 tCO₂e.)

In line with the Saudi Green Initiative, which has a target to plant 10 billion trees and increase the percentage of protected areas in Saudi Arabia to more than 30%, Aramco plans to invest in planting 31 million mangroves in the Kingdom by 2025, 300 million in Saudi Arabia by 2035, with a further and 350 million mangroves outside Saudi Arabia by the same date.

Carbon markets

Putting a price on carbon would be a key enabler for motivating investment in emerging technologies that are currently not cost-effective. Aramco favors and supports efficient and cost-effective ways to set a carbon price. We believe market mechanisms that address climate

What are we doing?



Captura

Captura, one of the latest startups invested in by Aramco Ventures, is exploring and looking to scale-up the potential for low-cost atmospheric carbon removal by leveraging the world's largest natural CO₂ absorber — the ocean. With minimal impacts on the environment and using only renewable electricity and ocean water as inputs, its patented electro dialysis process generates a stream of pure CO₂ that can then be sequestered or utilized to make other low carbon products.

Captura's ocean carbon capture represents an innovative and potentially cost-effective approach to reducing atmospheric CO₂. It can also be integrated with desalination infrastructure, which is already deployed at large-scale in Saudi Arabia.

change and sustainable development, and take the economic circumstances of developing countries into account, offer a good balance between driving emissions reductions and supporting economic growth.

To be effective, any framework or market-based mechanism 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.

Voluntary markets enable private investors, governments, non-governmental organizations, and businesses to purchase carbon credits to offset their emissions.

The Regional Voluntary Carbon Market

In 2022, Aramco signed a Memorandum of Understanding (MoU) with Saudi Arabia's Public Investment Fund to support the establishment of the Regional Voluntary Carbon Market in Riyadh and participated in its inaugural auction, where 1.4 million carbon credits were sold, of which 650,000 were purchased by Aramco.

1. For more information on [The Blue Carbon Initiative methodology](#).

The credits sourced through the auction are accredited by reputable international standards bodies compliant with globally accepted offsetting schemes (CORSI) and originate from a variety of carbon reducing projects in developing countries between 2018 and 2020.

Use of carbon offsets

Aramco is building a portfolio of carbon offsets that is either generated through the projects it invests in, or purchased in the voluntary carbon markets. These carbon offsets will be used to offset the Company’s residual emissions once we establish our annual targets.

Aramco is actively engaging in the development of global carbon markets through its memberships of the International Emission Trading Association and OGCI.

Additionally, through Aramco Venture’s Sustainability Fund, we are planning to invest in new technologies promoting the development of global voluntary carbon markets.

Leveraging technology

We have a track record of innovation and technology development and we recognize that a successful energy transition requires collaboration with a wide range of business and technology partners to develop the solutions needed:

- As the energy transition gathers pace, Aramco is leveraging technology and innovation toward a low carbon future and driving sustainable energy solutions across our business and the industries we supply; and
- We are innovating toward more sustainable solutions to help drive our positive impact on society and boost the quality of life for future generations.

What are we doing?

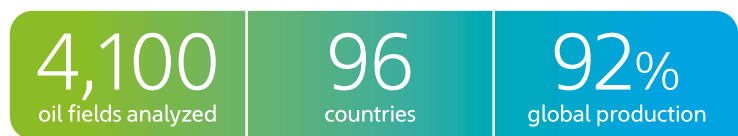
Embracing data-driven decision making: Aramco’s Support for the Archie Initiative

As part of our ongoing efforts to drive sustainability and transparency in the energy sector, we support the [Archie Initiative](#), an innovative scientific project aimed at enhancing GHG emissions estimations and fostering transparency within the global energy supply chain.

The Initiative brings together leading researchers, analysts, energy producers and thought leaders from academia and industry to collaborate and provide data on the carbon intensities of various energy sources, enabling better-informed decision-making.

The Initiative utilizes widely accepted life cycle analysis methods to enable a scientifically robust assessment and quantification of GHG emissions from various stages of the energy supply chain worldwide.

We believe our partnership can contribute to a more data-driven energy sector, promoting more sustainable and responsible energy choices for the benefit of shareholders, customers, and the global community.

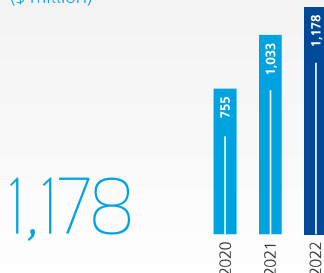


In 2022, our sustainability-related R&D was \$435 million², which equated to 59% (an increase of 7% from 2021) of total 2022 R&D spend of \$737 million³. Our R&D spend encompassed sustainability focused solutions to improve our business and energy efficiency, lower our carbon footprint and enhance company circularity, as well as supporting the global energy transition towards a lower carbon emissions future.

R&D focus areas	2021 spend (\$ million)	2022 spend (\$ million)
CCS	24.7	41.5
Renewable energy	9.3	6.4
Energy efficiency	55.9	64.8
Waste management and recycling	31.1	32.3
Water management	29.7	32.2
Gas treatment	21.4	40.5
Low carbon hydrogen	25.6	26.4
Sustainable mobility	94.0	136.6
Crude to chemicals	7.8	30.3
Non-metallic applications	15.5	24.2
Total R&D for sustainability technologies^{2,3}	315	435
Total Aramco R&D^{2,3}	607	737
% of sustainability-related R&D out of Aramco R&D spend^{2,3}	52%	59%

Total R&D spend¹

(\$ million)



1. Total Group R&D including SABIC.
 2. Includes direct R&D program costs plus estimated overheads.
 3. Does not include SABIC R&D expenses.

Examples of ongoing R&D initiatives include:

- Innovative technologies and processes for the utilization of CO₂ in various applications to deliver alternative sequestration pathways;
- Cost-competitive technology for large-scale CO₂ capture from air for reusing it for e-fuels or storage;
- New technologies that optimize/aid in the integration of alternate energies into upstream operations, reducing emissions associated with power consumption;
- Cost-effective and efficient onsite hydrogen and electricity generation systems to provide low carbon hydrogen and electricity for transport;
- With leading engine manufacturers, developing and demonstrating efficiency – and therefore reduced emissions – in internal combustion engines utilizing CO₂, and emissions solutions;
- Converting crude oil directly to chemicals to optimize or eliminate several energy intensive industrial processes;
- In plastics, develop technologies and processes to reduce material and chemical consumption, and increase recycling; and
- Reduce emissions associated with water processing and disposal/re-injection through reduced water production, recycling and reuse.

IR 4.0 — the Global Lighthouse Network

Three of our larger facilities have been accredited by the Global Lighthouse Network, a group of industrial sites that the World Economic Forum has identified as pace-setting in implementing Fourth Industrial Revolution technology at scale.

The latest addition to the network is our Abqaiq Plant, the largest crude stabilization plant in the world. It joins Khurais Producing facility and our 'Uthmaniyah gas plant. Aramco is the only major energy firm represented — a testament to our commitment to IR 4.0 technologies and to the scale of our ongoing digital transformation.

Aramco's digital transformation has affected almost every aspect of our Abqaiq Plant's operations, with three key changes:

First, the use of robots and drones equipped with cameras, thermal imagers, and gas detectors reducing reliance on in-person checks.

Second, the introduction of machine learning and AI powered algorithms has enabled a continuous and proactive digital adjustment of the oil stabilization process — leading to a 4.5% increase in energy efficiency since 2019, as well as a reduction in CO₂ emissions.

Third, the use of data analytics and predictive modeling has enabled our engineers to anticipate potential disruptions more effectively.

