

# 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 CO<sub>2</sub> 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 CO<sub>2</sub> 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 CO<sub>2</sub> 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.



### CO<sub>2</sub> mineralization

Aramco is developing novel methods for permanently sequestering CO<sub>2</sub> through mineralization. We have demonstrated one such method through a pilot technology that stored up to 200 kg of CO<sub>2</sub> per ton of cement while curing precast concrete at a local plant. Additionally, Aramco and KAUST piloted a novel CO<sub>2</sub> sequestration solution using mineralization, which involves dissolving CO<sub>2</sub> in water and injecting it into volcanic rocks in Jazan, Saudi Arabia. The process permanently converts CO<sub>2</sub> 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.