

Hydrogen Technology for Low-Carbon Solutions

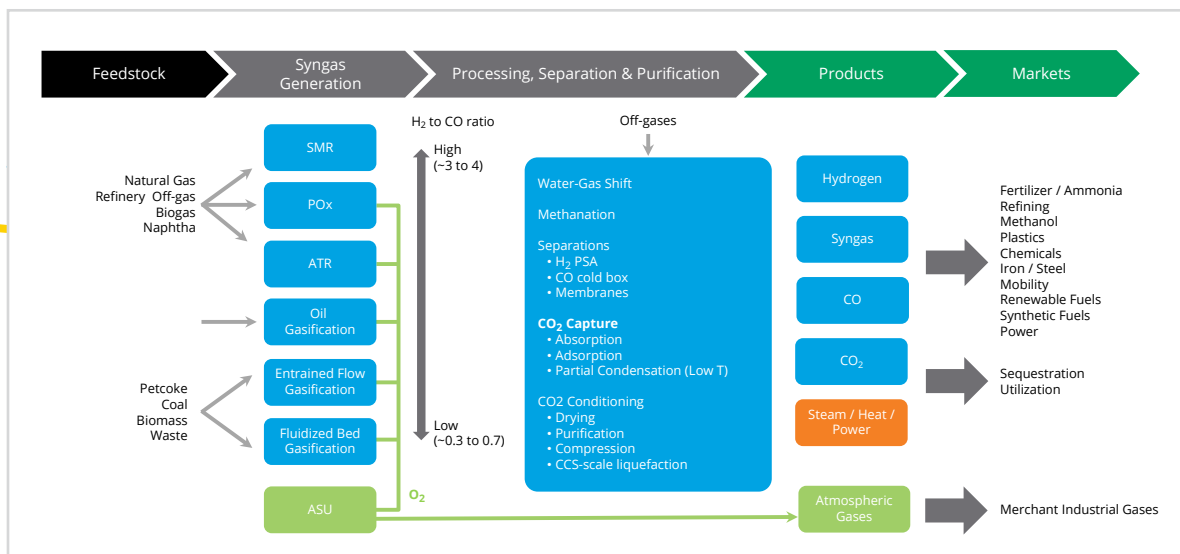


Figure 1: Blue H2 & CCUS Portfolio

Benefits of Air Products' low carbon technologies

- A diverse portfolio of technologies enables optimised hydrogen and syngas solutions considering technical, economic, and legislative factors
- Multi-facility integration and monetization of co-products are key enablers of value creation for all stakeholders
- An integrated approach to technology development and operational excellence has led to superior safety, reliability, and cost performance

Air Products operates in approximately 50 countries, serving clients globally with a unique portfolio of products and technologies in dozens of industries including refining, LNG, chemicals, metals, electronics, and manufacturing.

The company's integrated approach to research, development, production, and distribution of industrial gases is a key competitive advantage, helping it become a leading player in this space. Leveraging its integrated platform, Air Products is executing an ambitious growth plan driven by its mission to support clients through the energy transition with environmentally sustainable solutions.

Air Products has successfully demonstrated large-scale carbon capture at its Port Arthur hydrogen facility in Texas. Operating since 2013, key learnings from this project have helped the company develop the next generation of low-carbon hydrogen projects in its franchise. In Canada, the Net-Zero Hydrogen Energy Complex, targeted for 2024, incorporates +95% carbon capture and hydrogen-fired power generation. In the U.S. Gulf Coast, the Louisiana Blue Hydrogen Clean Energy Complex, targeted for 2026, includes the development of one of the world's largest carbon sequestration operations.

Air Products' diverse portfolio of technologies enables (figure 1) hydrogen and syngas production from a variety of feedstocks with diverse options for carbon capture, sequestration and/or utilization. The company maximises value for all stakeholders by operating an integrated industrial gases platform that is continuously focused on safety, reliability, and cost.

Continuously refining and optimizing our hydrogen and CCUS technologies

Air Products is an industry leader with expansive operations, continuously refining and optimizing its technology portfolio at research and engineering centers located in the United States, Europe, Saudi Arabia, India, and China. A global team of engineering and construction professionals are responsible for bringing these technologies to life, building world-scale industrial gas projects including carbon capture, utilization, and sequestration (CCUS) facilities. Completing the technology lifecycle, as one of the sector's largest operators, Air Products gathers real-world data and experience for technology refinement, achieved through cross-collaboration between research, engineering, and operations teams. The integrated approach to technology and operational excellence is a major source of strength and differentiation, leading to advantages in safety, reliability, and cost performance.



Net-Zero Hydrogen Energy Complex in Edmonton, Canada

In advancing its decarbonization mission forward, Air Products is building the Net-Zero Hydrogen Energy Complex (figure 2) in Edmonton, Canada to integrate and decarbonize its Alberta Heartland Hydrogen Pipeline System. Engineering work is currently underway, and the facility is targeted to start up in 2024. Hydrogen will be produced using autothermal reformer (ATR) technology integrated with carbon capture systems achieving +95% capture. The facility will be self-powered using hydrogen-fired turbines and will also export power, helping further reduce emissions by offsetting higher carbon intensity electricity on the grid. Low-carbon intensity hydrogen will be distributed along the ~55 km (~34 mile) Heartland Pipeline System to multiple offtakers, as well as liquified on-site for distribution to merchant and mobility markets by Air Products' road fleet. This is a common theme across Air Products' portfolio where integration allows for enhanced value creation.

Air Products can tailor solutions for each facility

When developing low-carbon hydrogen projects, Air Products tailors facility configurations from an extensive portfolio of technologies (figure 1). With multiple technologies available for each step of the process, Air Products develops an optimised and integrated solution considering technical, economic, and legislative factors. Hydrogen and syngas generation can be designed for a wide variety of feedstocks, as shown, allowing carbon capture from any input stream including solid, liquid, or gaseous hydrocarbons, waste, and/or biomass.

Blue Hydrogen Clean Energy Complex in Louisiana



Similarly in the U.S. Gulf Coast, the Louisiana Blue Hydrogen Clean Energy Complex (figure 3) moves the franchise further down the decarbonization path, utilizing natural gas gasification technology, also known as partial oxidation, to produce hydrogen whilst capturing +95% of the associated direct emissions. Air Products has identified the ideal geologic structure for CO₂ storage and will lead its development into one of the world’s largest sequestration operations. Once fully commissioned, over 5 million tonnes of CO₂ per year will be captured, transported, and sequestered in this dedicated underground storage facility.

The company’s holistic development approach creates opportunities for energy and product integration between different company-owned and/or client facilities. The Louisiana Blue Hydrogen Complex for example not only integrates into the Gulf Coast Hydrogen Pipeline System, described previously, but also serves a new ammonia plant to enable the global distribution of low-carbon intensity hydrogen molecules.

Figure 2: Net-Zero Hydrogen Energy Complex (Alberta, Canada)

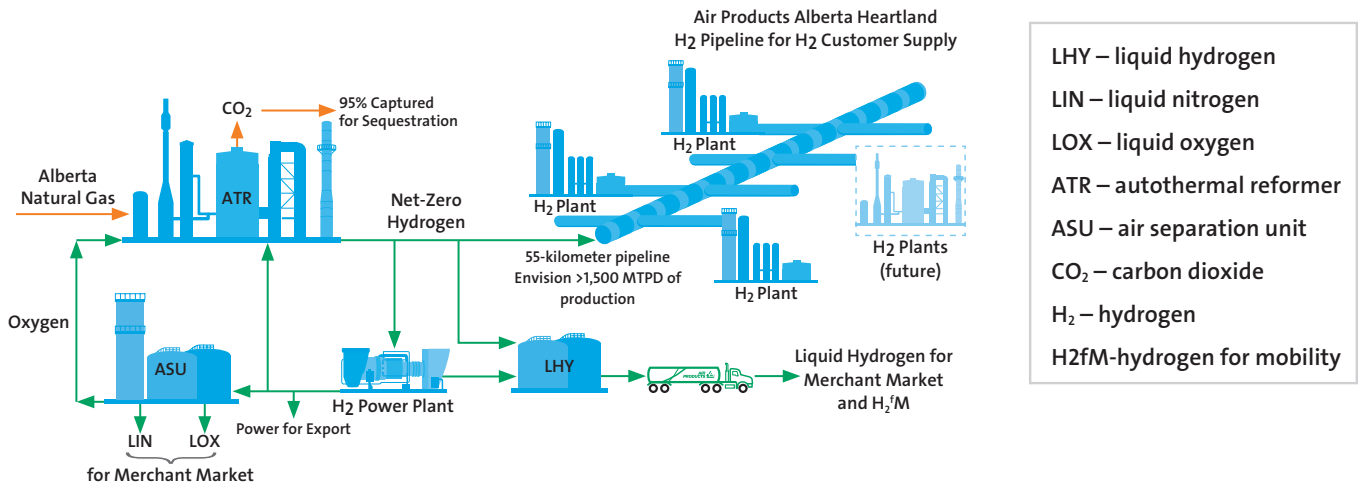
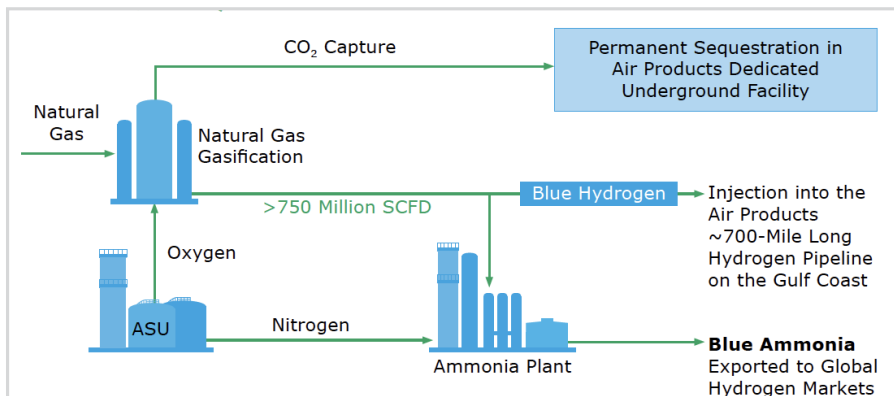


Figure 3: Blue Hydrogen Clean Energy Complex (Louisiana, USA)



Superior engineering, project execution, and operations capabilities

Air Products operates the world's longest hydrogen pipeline in the US Gulf Coast, linking about 25 hydrogen production plants across ~1,100 kilometers (~700 miles) from New Orleans to Texas City. Within the Gulf Coast System, the Port Arthur Blue Hydrogen plant in Texas approached 8 million tons of captured CO₂ as of 2021. The project, completed in 2013, entailed the retrofit of two existing steam methane reformers (SMR's) with carbon capture units to reduce +90% of high-pressure CO₂ in process streams, equating to approximately half of the direct emissions associated with hydrogen production. CO₂ is captured using vacuum swing adsorption (VSA) separation units, purified by a tri-ethylene glycol (TEG) dryer, compressed to supercritical pressures, and transported by Air Products via a ~21 km (~13 mile) pipeline to an offtaker. A cogeneration unit was integrated into the scope to further enhance efficiency and reduce emissions. The successful completion and operation of this retrofit project in the middle of an operating refinery was a testament to the company's engineering, project execution, and operations capabilities. Lessons learned from this project in capturing CO₂ from high-pressure streams were critical in developing the company's next generation of low-carbon hydrogen projects.

Extensive experience with designing and operating standalone CO₂ facilities

Air Products has extensive experience with designing and operating standalone CO₂ facilities in various scales including merchant CO₂ plants. The company also operates world-scale facilities such as the Doe Canyon Helium Plant in Colorado where approximately 9,000 tonnes per day of CO₂ are separated from Helium using a patented partial condensation separation process.

Air Products is executing an ambitious growth plan driven by its mission to support clients through the energy transition with environmentally sustainable products and solutions. **The company can help maximize value for all stakeholders through early engagement in project conception and execution.**

For more information,
please contact us at:

Air Products and Chemicals, Inc.

1940 Air Products Boulevard
Allentown, PA 18106-5500
T 800-654-4567
F 800-272-4449
info@airproducts.com

Canada

Air Products Canada Ltd.
2233 Argenta Rd., Suite 203
Mississauga, ON L5N 2X7
T 800-654-4567 or 905-816-6670
info@airproducts.com



tell me more
airproducts.com