United States House of Representatives

Committee on Science, Space and Technology

November 22, 2019

Field Hearing on the "The Future of Advanced Carbon Capture Research and Development"

Testimony of
Roger A. Dewing
Air Products and Chemicals, Inc.

Mr. Chairman, Ranking Member and members of the Committee, I appreciate the opportunity to testify before you today. My name is Roger A. Dewing, Director of Technology, CCUS, at Air Products and Chemicals, Inc.

First, I want to commend the leadership of this Committee for exploring the promise of carbon capture technology and its importance to global energy.

I'd like to start by outlining how Air Products believes Carbon Capture and Storage, or CCS, projects may develop over the next few years. I'll highlight how important these projects could be in reducing carbon dioxide emissions to the atmosphere whilst maintaining global energy supplies.

Many of the current proposed CCS projects revolve around the production and utilisation of hydrogen. Hydrogen may be the enabler for many CCS projects. If current hydrocarbon fuels, from natural gas to coal, are converted to hydrogen and carbon dioxide, or CO_2, and if the carbon dioxide is captured and stored, then the produced hydrogen can be considered to have been produced emission-free. This is being referred to as “Blue Hydrogen.”

Using hydrogen to distribute and store energy has some significant benefits. It can be used as the fuel for power generation in turbines. It can be used for transportation using fuel cells. It can be distributed to industry clusters to decarbonise energy intensive industries.

Excess hydrogen can be stored for use when demand is high. It can therefore be complementary to green energy projects such as solar or wind, providing a backup supply of energy when needed.

However, CCS projects will only become a reality if you can you answer two fundamental questions. Where will the CO_2 go, and who will pay for it to be captured and stored. I will explore these questions again in a moment.

Within Air Products I'm currently setting up a group to further develop our CCS technology, recruiting scientists and engineers into our U.S. head office in Pennsylvania and elsewhere. This is to meet the need for greater sustainability in global industrial projects.

Air Products' initial interest in CCS started in 2005 when these types of projects were being led by large power generation companies. However, global interest diminished with the recession of 2008. Interest is returning, but with a different focus. Current proposals are for a group of multiple projects feeding a separate single CO_2 storage solution. The US, Canada, EU, and China are leading this renewed interest.

The U.S. is the market leader for CCS projects and associated technology. Currently, over half the operating CCS projects around the world are in the U.S. There are already hundreds of miles of supercritical CO_2 pipelines moving large quantities of CO_2 for enhanced oil recovery known as EOR, and the federal 45Q tax credits provide financial incentives to capture CO_2. I would argue that this credit may not be enough on its own, but it is ahead of other countries who have yet to put this important funding in place.

Among the current CCS projects operating is Air Products' Port Arthur facility, here in Texas. It originally produced hydrogen and steam for refinery customers, but since a retrofit completed in 2013, it also captures 1 million metric tonnes per year of CO_2. The project was partially funded by the DOE which allowed us to develop our CO_2 Vacuum Swing Adsorption technology that can flexibly capture CO_2 from the process gas. Air Products also installed equipment for the compression and drying of the CO_2 so that it could be delivered to a local Denbury-owned CO_2 pipeline for EOR. We were also able to reconfigure the facility such that it still provides the same industrial gas products to our customers.

This capture project is still operating and is a success because it answers those two fundamental questions I posed earlier, where will the CO_2 go and who will pay for it to be captured and stored. First, the Denbury CO_2 pipeline, used to supply CO_2 for EOR, was only 13 miles away, so there was a home for the CO_2. Secondly, the DOE funding for the project, the 45Q tax credits, and fact that CO_2 has a value for EOR meant the project made financial sense.

Looking to the future, Air Products is actively seeking more projects like Port Arthur. That experience gives us a proven reference of designing and operating CCS projects. It is likely that many of the next projects may be of similar scope. Retrofits of existing hydrogen facilities lend themselves to capturing significant CO_2 at modest capital cost.

Air Products' recent acquisition of Shell and GE gasification technologies should offer another opportunity to develop CCS projects. Gasification technology converts a broad range of hydrocarbon feedstock into hydrogen rich synthesis gas. It is then possible to capture the CO_2 from this gas for storage. This means fuels such as coal can be used for energy supplies, with theoretically no CO_2 emissions to the atmosphere.

We also plan to extend the proven technology deployed at Port Arthur to increase capacity and improve its efficiency and reliability.

Some final thoughts. The use of fossil fuels will continue for many years to come and CCS will allow this to continue whilst still meeting CO_2 emission targets. CCS means the heavier carbon rich fuels may still be used to provide energy without the associated heavy burden of atmospheric CO_2 emissions.

CCS projects are in operation today, so the technology to capture and store CO_2 already exists and is reliable. There are no technology barriers to projects, but further research will be essential to reduce costs and improve efficiency. This will make more projects feasible when the two fundamental questions are asked and answered.

Thank you for the opportunity to present Air Products' perspective on CCS issues and I hope that with the continued support of the DOE that many more CCS projects like our Port Arthur facility will become reality.

The Future of Advanced Carbon Capture Research and Development: An Air Products Perspective

Roger Dewing
Director of Technology for CCUS, Air Products

Hydrogen as an enabler

- Decarbonisation of hydrocarbons with CCS provides an energy source with zero or very reduced CO_2 emissions
- Produced hydrogen allows for decarbonised energy distribution and energy storage
  - Transportation
  - Heating and power
  - Energy intensive industry
- Integrated with green energy projects, it can provide carbon neutral energy storage and back-up
- Viable projects will only happen if you can answer two fundamental questions:

Where will the CO_2 go?
Who will pay?

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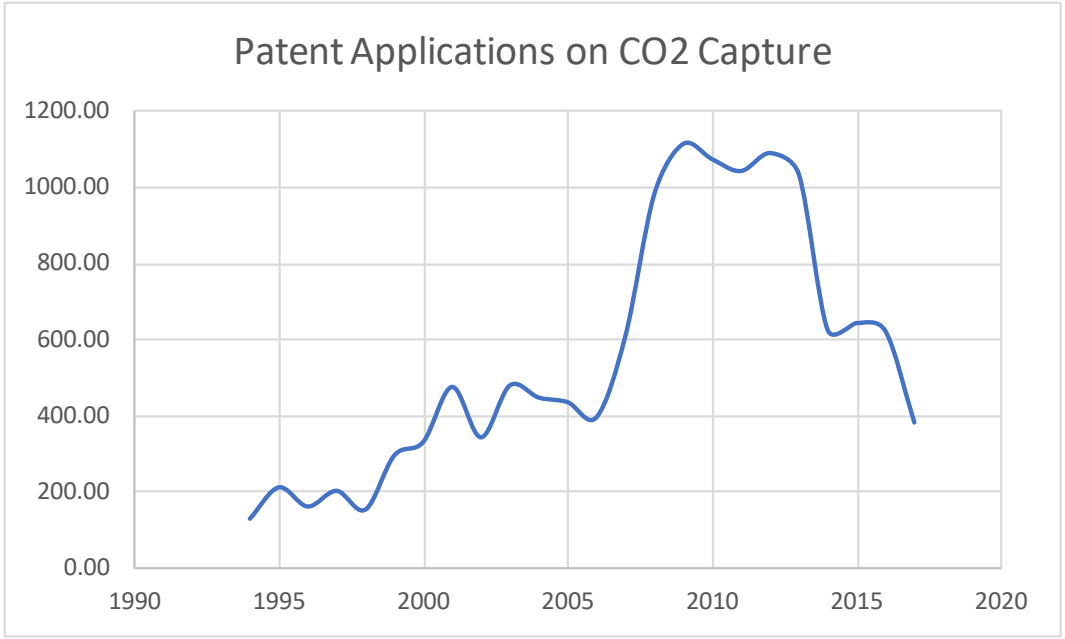
The Rise and fall …and rise? …of CO_2 capture

- Power companies drove interest in CO_2 capture from large coal power station 2005-2012
- 2008 recession eventually led to demise of most projects – the US being the exception due to existing enhanced oil recovery (EOR) demand for CO_2
- Renewed interest in US, EU, Canada, China
  - Multiple projects with a single storage solution
  - Energy clusters with hydrogen integration for distribution and storage



US leadership in CCS Projects

- More operating projects than ROW combined
- 100s of miles of existing super critical CO_2 pipelines for EOR
- Long term EOR experience
- Federal 45Q – Tax credit provided for projects that capture and store CO_2.
  - Updated in 2018
    - $35/MT for use in enhanced oil recovery (EOR)
    - $50/MT for sequestration

Project	Location	Onstream	Sector
Century Plant	Texas, United States	Operating since 2010	Industry, Natural Gas Processing
Terrell Natural Gas Processing Plant (formerly Val Verde)	Texas, United States	Operating since 1972	Industry, Natural Gas Processing
Petra Nova Carbon Capture	Texas, United States	Operating since 2017	Power, Coal Power Generation
Air Products Steam Methane Reformer	Texas, United States	Operating since 2013	Industry, Hydrogen Production
Enid Fertilizer	Oklahoma, United States	Operating since 1982	Industry, Chemicals (ammonia)
Coffeyville Gasification Plant	Kansas, United States	Operating since 2013	Industry, Chemicals (ammonia)
Illinois Industrial Carbon Capture and Storage	Illinois, United States	Operating since 2017	Industry, Refining (biofuels)
Shute Creek Gas Processing Plant	Wyoming, United States	Operating since 1986	Industry, Natural Gas Processing
Lost Cabin Gas Plant	Wyoming, United States	Operating since 2013	Industry, Natural Gas Processing
Great Plains Synfuel Plant and Weyburn-Midale	North Dakota, United States & Saskatchewan, Canada	Operating since 2000	Industry, Refining (SNG)

CCS North America (ref International Energy Agency)

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Project Overview: State-of-the-Art Carbon Capture from Two Port Arthur, TX SMRs

- American Recovery and Reinvestment Act Funding
- ~1 million tons of CO2 to be recovered and purified annually starting late 2012
- Valero providing land, rights-of-way, utilities
- Air Products supplying compressed and purified CO_2 to Denbury for injection into TX oilfields for enhanced oil recovery

U.S. DEPARTMENT OF ENERGY

VALERO

Denbury

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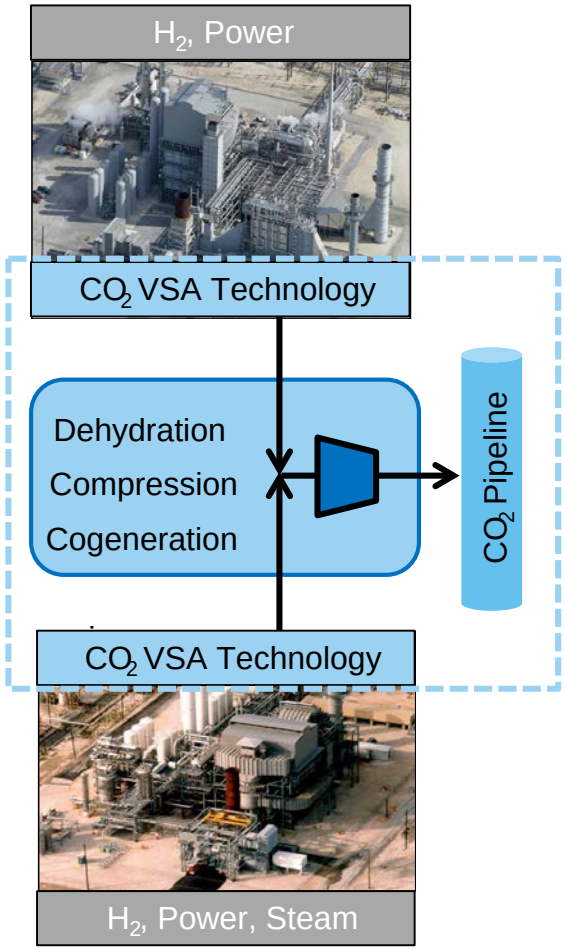
Air Products' Port Arthur CO2 Project

Technology to recover anthropogenic CO_2 for EOR



- Retrofit of two Steam -Methane Reformers (SMR) located in the middle of a refinery
- Capture and purification of CO_2 from hydrogen plants for EOR
- Technology developed by Air Products
  - Vacuum Swing Adsorbers
- 90%+ capture of CO_2 from syngas
- ~2600 t/d (50 MMSCFD) of CO_2 to Denbury's Green Pipeline for West Hastings oilfield EOR
- 30 MWe cogeneration unit to generate power and make-up steam
- Full capacity achieved April 2013

Capturing 1 million tonnes/year of CO_2 since 2013

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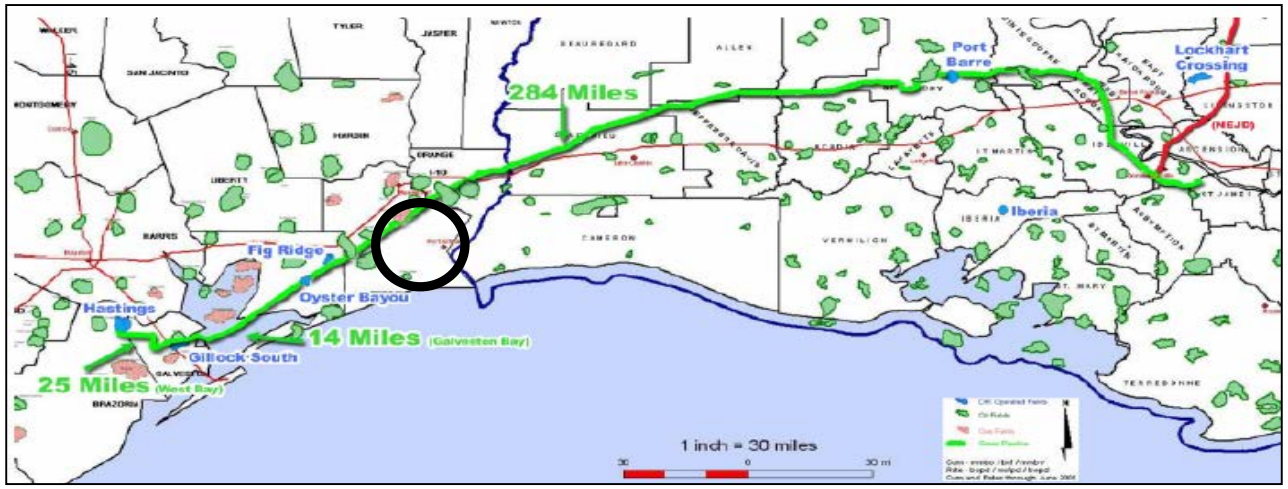
CO_2 Capture – Port Arthur Project Answers

- **Where will the CO_2 go?**
  - Port Arthur is 13 miles (21 km) from Denbury's existing "Green" 300+ Mile (~500 km) CO_2 Pipeline used for CO_2 EOR
- **Who will pay for the CO_2 capital and operating costs?**
  - US Government grant from the American Recovery & Reinvestment Act
  - Tax credits 45Q for CO_2 stored by EOR
  - Denbury pays for CO_2 to use in EOR applications



Map shows Denbury's Green CO_2 Pipeline.
Data source is Denbury, December 2011, CO_2 Flooding Conference

Air Products' CCS focus

- Looking for viable CCS opportunities
- Further retrofits of existing hydrogen SMRs
- CO_2 Capture from Gasification
  - In preparation Air Products has purchased key Gasification technology of the leading suppliers
  - Gasification with CO_2 capture allows you to use high carbon content feed stocks to produce high value products with minimal carbon emissions
  - Air Products has developed a "Road Map" of technology applications for CO_2 capture on coal and refinery heavy residue feedstocks
- Development of in-house technology e.g. CO_2 VSA
- Decarbonization of natural gas
- Partnerships for storage options

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Summary

- Fossil fuels will be part of the global energy supply for a many years to come
  - CCS means we can continue whilst meeting CO_2 emission targets
- CCS allows the use of lower cost carbon rich "heavy" feedstocks with low atmospheric CO_2 emissions
- All the necessary technology to capture, purify and store CO_2 exists and is proven in long term operation
  - Technology available to commence projects immediately
  - R&D will improve efficiency and reduce cost
- A competitive alternative to other Green Energy projects
- Seed projects can be an enabler for further R&D, pilot plants, smaller scale investments

Where will the CO_2 go?
Who will pay?

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Thank You

tell me more

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Roger Dewing, Director of Technology for Carbon Dioxide Capture, Utilization and Storage (CCUS)

Roger graduated from the University of Surrey, UK, with a bachelor's degree in Chemical Engineering in 1988. He joined the Italian EPC, Snamprogetti, on their UK graduate training program, then joined British Gas plc as part of their LNG engineering team.

Since joining Air Products in 1996 Roger has worked in a variety of technology areas, leading Engineering teams in Europe, China and US. Significant career highlights include the technology development for multi-train Air Separation facilities, Hydrogen Steam Methane Reformer projects, novel Helium extraction processes, cryogenic syngas purification facilities, and a rare gas extraction facility in Saudi Arabia.

In 2017 Roger transitioned from the Global Technology Manager for cryogenic processes to undertake the development of the Air Product Technology Center located in the Dhahran Techno Valley, Saudi Arabia, building a world class organization to support Air Products businesses in the Middle East.

Roger has recently been appointed as the Director of Technology for CCUS, leading the recruitment and development of a new team. The objective is to increase the level of Air Products participation in sustainability and GHG mitigation projects by seeking to accelerate the technology development for Carbon Dioxide capture, purification, utilization and storage.