

**COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES**

HEARING CHARTER

*The Future of Advanced Carbon Capture Research and
Development*

Friday, November 22, 2019

10:00 a.m.

Houston, TX

PURPOSE

The purpose of the hearing is to examine the state of advanced carbon capture, utilization, and storage (CCUS) technologies and practices in the United States and to determine how the Federal government can best accelerate this growing area of research in support of U.S. interests in energy security, environmental stewardship, and national security.

WITNESSES

- **Dr. Ramanan Krishnamoorti**, Chief Energy Officer, Professor of Chemical Engineering, University of Houston.
- **Dr. Jeffrey Long**, Faculty Senior Scientist, Materials Sciences Division, Lawrence Berkeley National Laboratory.
- **Mr. Greg Kennedy**, Senior Project Director, NRG Energy; and Director of Asset Management, Petra Nova Project.
- **Mr. Roger Dewing**, Director of Technology CCUS, Air Products and Chemicals Incorporated, Inc.
- **Mr. Nigel Jenvey**, Global Head of Carbon Management at Gaffney, Cline & Associates.

BACKGROUND:

Today in the United States, fossil energy sources account for over 77% of our total energy use and are responsible for approximately 76% of total U.S. anthropogenic greenhouse gas emissions, the vast majority of which are carbon dioxide (CO₂) based.^{1,2} As a result, while U.S. national security and economic growth are reliant on continued access to these critical resources, there is growing interest in addressing CO₂ emissions generated by the use of fossil fuels.

Support of fundamental research to enable the development of emissions management and reduction strategies can play an important role in addressing this challenge. One leading opportunity to reduce emission is through carbon capture, utilization, and storage (CCUS) technologies. CCUS technologies involve the capture of CO₂ from fuel combustion or industrial

¹ U.S. Department of Energy, *FY 2020 Congressional Budget Request*, Vol. 3, Part 1, ENERGY.GOV (March 2019), https://www.energy.gov/sites/prod/files/2019/04/f61/doe-fy2020-budget-volume-3-part-1_0.pdf.

² U.S. Energy Information Administration, *Energy and the environment explained*, EIA.GOV (Jun. 19, 2019), <https://www.eia.gov/energyexplained/energy-and-the-environment/where-greenhouse-gases-come-from.php>.

processes to be either used for products and services, or deposited in permanent storage sites.³ Carbon capture R&D involves novel compression technologies for fossil fuel-fired power plants and innovative gas separation technologies, including techniques like non-aqueous solvents, advanced membranes, and cryogenic processes in both the post-combustion and pre-combustion space.⁴ Carbon capture R&D is supported by advanced computational tools that will help in material discovery and design of innovative system components.

Carbon utilization R&D often focuses on captured carbon use for various products and applications through the development of advanced catalysts, reactor systems, and efficient CO₂ conversion processes. Through research that explores opportunities to use carbon in industrial chemicals and polymers, mineralization to building products, and conversion to animal feed, there is the potential for carbon utilization to develop additional markets for fossil energy resources.⁵

Carbon storage R&D includes the development of technologies that can safely and permanently store captured CO₂ in geologic formations, particularly depleted oil and gas fields. Captured carbon can be stored in deep saline formations and injected for enhanced oil recovery (EOR) operations.⁶ Simulation tools, characterization methods, and monitoring technologies have the potential to increase storage efficiency, reduce overall costs, and decrease subsurface uncertainties.⁷

By improving the performance and reducing the cost of these technologies, CCUS research can encourage the adoption and use of technologies to capture CO₂, and potentially increase its market potential.⁸

Houston, Texas

Houston, Texas, often called the “Energy Capital of the World”, is home to 4,600 energy firms, employs nearly a third of U.S jobs in oil and gas extraction, and is uniquely positioned to lead in CCUS technology acceleration.⁹ At this hearing, we will hear testimony from Dr. Ramanan Krishnamoorti, the Chief Energy Officer at the University of Houston (UH) who leads UH Energy, an umbrella for efforts across the University of Houston system to allow the university to serve as a strategic partner to the energy sector, and the CCUS industry both at home and abroad.¹⁰

³ International Energy Agency, *Carbon Capture, Utilisation and Storage*, IEA.ORG, <https://www.iea.org/topics/carbon-capture-and-storage/> (last visited Nov. 20, 2019).

⁴ *Ibid.*

⁵ National Energy Technology Laboratory, *About Carbon Utilization*, NETL.DOE.GOV, <https://netl.doe.gov/coal/carbon-utilization/about> (last visited Nov. 20, 2019).

⁶ U.S. Environmental Protection Agency, *Carbon Dioxide Capture and Sequestration: Overview*, EPA.GOV (Jan. 19, 2017), https://19january2017snapshot.epa.gov/climatechange/carbon-dioxide-capture-and-sequestration-overview_.html.

⁷ U.S. Department of Energy, *Carbon Storage R&D*, ENERGY.GOV, <https://www.energy.gov/fe/science-innovation/carbon-capture-and-storage-research/carbon-storage-rd> (last visited Nov. 20, 2019).

⁸ *About Carbon Utilization*, *supra* note 5.

⁹ Great Houston Partnership, *Energy*, HOUSTON.ORG, <https://www.houston.org/why-houston/industries/energy> (last visited Nov. 20, 2019).

¹⁰ University of Houston, *Research: Dr. Ramanan Krishnamoorti*, UH.EDU, <https://uh.edu/uenergy/research/krishnamoorti-ramanan.php> (last visited Nov. 20, 2019).

We will also hear testimony from Mr. Nigel Jenvey, Global Head of Carbon Management at Gaffney, Cline & Associates who has decades of global fossil energy experience in technology, exploration, development, and production operations with major oil and gas operating companies in the Houston area and is an industry leader in CCUS technologies.¹¹

DOE Office of Fossil Energy Research and Development

Within the jurisdiction of the Committee on Science, Space, and Technology, the Department of Energy (DOE) funds CCUS relevant fossil energy research. The DOE Office of Fossil Energy Research and Development (FER&D) supports applied research, development, demonstration, and commercialization activities for the advancement of technologies related to the reliable and environmentally sound use of fossil energy sources. In this capacity, FER&D conducts cross-cutting research on advanced fossil energy systems, and enables the development of innovative carbon capture, utilization, and storage (CCUS) technologies with application to both new and existing fossil fuel facilities. In fiscal year (FY) 2019, FER&D was funded at \$740 million.¹²

Much of this research is carried out through DOE's world-leading national laboratories like the National Energy Technology Laboratory (NETL) in Pennsylvania, which is the Department's applied energy lab specifically dedicated to fossil energy research and development and a leader in developing CCUS technologies.¹³ However, much of this applied research is supported by efforts throughout the national laboratory system, including the Department's Office of Science laboratories like Lawrence Berkeley National Laboratory (LBNL) in California.¹⁴

LBNL provides CCUS researchers with the necessary research infrastructure and expertise in advanced scientific computing and materials science that lay the foundation for innovative CCUS R&D. At this hearing, we will hear testimony from one of these researchers, Dr. Jeffrey Long, a Professor of Chemistry at the University of California Berkeley and Faculty Senior Scientist in the Materials Sciences Division at LBNL. Dr. Long's research focuses on the development of novel metal-organic frameworks (MOFs) for applications in hydrogen storage and CO₂ capture, a discovery that was enabled by Federal investments in fundamental science.¹⁵

Public-Private Partnerships

The U.S. fossil energy industry has an established history of leveraging DOE investments in R&D to achieve transformative technology breakthroughs. This tradition of successful public-private partnerships between DOE FER&D and the private sector has continued with the emerging U.S. CCUS industry.

¹¹ Gaffney, Cline & Associates, *Authors: Nigel Jenvey*, GAFFNEY-CLINE-FOCUS.COM, <http://gaffney-cline-focus.com/author/nigel-jenvey> (last visited Nov. 20, 2019).

¹² *FY 2020 Congressional Budget Request*, *supra* note 1.

¹³ National Energy Technology Laboratory, *Mission and Overview*, NETL.DOE.GOV, <https://netl.doe.gov/about/mission-overview> (last visited Nov. 20, 2019).

¹⁴ Dan Krotz, *New Carbon Capture Membrane Boasts CO₂ Highways*, LAWRENCE BERKELEY NATIONAL LABORATORY (Mar. 17, 2016), <https://newscenter.lbl.gov/2016/03/17/carbon-capture-membrane/>.

¹⁵ The Long Group, *Metal-Organic Frameworks*, BERKELEY.EDU, <http://alchemy.cchem.berkeley.edu/mofs/> (last visited Nov. 20, 2019).

One example of DOE's ongoing partnerships with the CCUS industry is NRG and JX Nippon's coal-powered Petra Nova plant in southwest Texas. After receiving a \$190 million grant from DOE, NRG joined with JX Nippon in a 50/50 joint venture to finance the project, along with a joint venture with Hilcorp Energy to leverage the untapped potential of the West Ranch oil field.¹⁶ Petra Nova is one of only two operating power plants utilizing carbon capture technology in the world, and it is the only such facility currently operating in the United States.¹⁷

Petra Nova captures approximately 90% of the CO₂ emitted from the flue gas slipstream of an existing coal-fired generating plant.¹⁸ This captured carbon is then injected into mature local oil reservoirs to enhance West Ranch oil field production. Within the first 10 months of the start of operations in 2016, the Petra Nova plant has delivered more than 1,000,000 tons of captured carbon dioxide and boosted oil production 1,300 percent.¹⁹

Another DOE public-private partnership in CCUS is Air Products and Chemicals, Inc.'s carbon capture system located within the Valero Port Arthur Refinery in Port Arthur, Texas. Air Products is a public industrial gases and materials company with an international presence in CCUS technologies. In support of this innovative facility in Texas, DOE provided a total of \$284 million, or 66% of the over \$400 million project.²⁰

The first project of its kind to begin operations at commercial scale, this facility captures CO₂ from steam methane reformers (SMRs), which is then transported by pipeline to Denbury Onshore's West Hasting Unit to assist in enhanced oil recovery. DOE has estimated that 1.6 to 3.1 million barrels of oil will be produced annually from this CO₂ application process.²¹

At this hearing we will hear testimony from Mr. Greg Kennedy, a Senior Project Director for NRG Energy, Inc. who serves as the Asset Manager for the Petra Nova Project, and from Mr. Roger Dewing, the Director of Technology CCUS at Air Products and Chemicals, Inc. who will highlight these important industry success stories and provide key insight into private sector needs for future Federal partnerships in CCUS and fossil energy technologies.

¹⁶ U.S. Department of Energy, *Petra Nova – W.A. Parish Project*, ENERGY.GOV, <https://www.energy.gov/fe/petra-nova-wa-parish-project> (last visited Nov. 20, 2019).

¹⁷ Kenneth Dubin, *Petra Nova is one of two carbon capture and sequestration power plants in the world*, U.S. ENERGY INFORMATION ADMINISTRATION (Oct. 31, 2017), <https://www.eia.gov/todayinenergy/detail.php?id=33552>.

¹⁸ NRG Energy, *Case Studies: Petra Nova*, NRG.COM, <https://www.nrg.com/case-studies/petra-nova.html> (last visited Nov. 20, 2019).

¹⁹ *Ibid.*

²⁰ Air Products, *Air Products Signs Two Agreements to Move Texas Carbon Capture and Sequestration Project Forward*, AIRPRODUCTS.COM (May 26, 2011), <http://www.airproducts.com/company/news-center/2011/05/0526-air-products-signs-two-agreements-for-texas-carbon-capture-and-sequestration-project.aspx>.

²¹ Air Products, *Air Products Celebrates Texas Carbon Capture Demonstration Project Achievement*, AIRPRODUCTS.COM (May 10, 2013), <http://www.airproducts.com/Company/news-center/2013/05/0510-air-products-celebrates-texas-carbon-capture-demonstration-project-achievement.aspx>.