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Examining the U.S. Department of Energy's Carbon Capture, Utilization and Storage Programs and Receive Testimony on S.1201, the Enhancing Fossil Fuel Energy Carbon Technology Act of 2019

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Thank you, Chairman Murkowski, Ranking Member Manchin, and Members of the Committee. I appreciate the opportunity to be here today, and it is my pleasure to appear before you to discuss how the Department of Energy (DOE) is advancing an important part of DOE's Fossil Energy (FE) research and development (R&D) portfolio — the commercial deployment of carbon capture, utilization, and storage (CCUS) technologies. With the Committee's ongoing support, we are backing up our commitment to CCUS with the R&D necessary to advance these technologies, improve our environmental footprint, and advance U.S. world leadership in this critical area.

The American taxpayer has invested nearly $4 billion in CCUS since 2010. We are approaching the point at which the American taxpayer will receive return from this investment. Just over the horizon, we see energy generation technologies that can deliver electricity with near-zero greenhouse gas (GHG) emissions at some of the lowest costs in the world. We also see a robust enhanced oil recovery (EOR) industry that can produce oil with 37 percent less CO_2 emissions on a life-cycle basis.

So far this fiscal year we have:

- Selected carbon capture technology projects totaling $24 million;
- Announced $30 million for front-end engineering and design (FEED) studies for capture systems on both coal and natural gas power plants;
- Announced $20 million for a regional initiative to accelerate CCUS, and we plan to release a $30 million Funding Opportunity Announcement for large-scale CO_2 storage projects through DOE's CarbonSAFE initiative that is focused on the development of geologic storage sites for CO_2;
- Selected multiple projects, totaling $13 million, to develop innovative methods for converting CO_2 into valuable products and chemicals through our Carbon Utilization program; and

- Launched the Coal FIRST (Flexible, Innovative, Resilient, Small, Transformative) initiative to enable industry to develop the coal plant of the future, which will provide secure, stable, reliable power with near-zero emissions, including CO_2. This early-stage R&D will support the development of coal-fired power plants that are capable of *flexible* operations to meet the needs of our evolving grid; use *innovative* and cutting-edge components that improve efficiency and reduce emissions; provide *resilient* power to Americans; are *small* compared to today's conventional utility-scale coal to meet the needs of distributed generation; and will *transform* how coal technologies are designed and manufactured.

Fundamental changes to the operating and economic environment in which coal plants function are expected to persist into the next decade and beyond. Deployment of new coal plants will require a different way of thinking. The need for dispatchable generation, critical ancillary services, grid reliability and energy security, such as the importance of onsite fuel availability during extreme weather events, creates an opportunity for advanced coal-fired generation both domestically and internationally. Right now, though, there is a pressing need to develop and implement policies that will provide financing and market certainty to support the development of CCUS supply chains, commercial infrastructure, and private sector investment.

With respect to S. 1201, the Enhancing Fossil Fuel Energy Carbon Technology Act of 2019, the Administration is currently reviewing this legislation and no position has been taken on this bill. S. 1201 directs the Department of Energy to support four programs focused on fossil energy R&D and carbon capture, utilization, and storage:

- A Coal and Natural Gas Technology Program to support large-scale pilot projects, demonstration projects, and the "development of technologies to improve the efficiency, effectiveness, costs, and environmental performance of coal and natural gas use."

- A Carbon Storage Validation and Testing Program to conduct research, development, and demonstration projects for carbon storage and establish a large-scale carbon sequestration demonstration program, with the possibility of transitioning to an integrated commercial storage complex.

- A Carbon Utilization Program to identify and assess novel uses for carbon, carbon capture technologies for industrial systems, and alternative uses for coal.

- A Carbon Removal Program for technologies and strategies to remove atmospheric carbon dioxide on a large scale.

As always, the Administration is ready to provide technical assistance as needed on this legislation moving forward.

All informed experts agree, commercializing and deploying CCUS technologies is a realistic path to reducing CO_2 emissions on a large scale. An integral piece to "jumpstart" this

deployment is financial incentives, such as section 45Q of the Internal Revenue Service code, which provides a tax credit on a per-ton (metric) basis for storing or utilizing captured CO_2. DOE is currently working with the Internal Revenue Service, the Department of the Treasury, the Department of the Interior, and the Environmental Protection Agency to resolve uncertainties regarding implementation.

FE's robust CCUS R&D program has produced some impressive successes, but technical hurdles to commercializing these technologies remain. The most significant hurdle is the cost associated with carbon capture, which needs to be reduced by about 50 percent to $30 a metric ton by 2030 to be competitive with alternative energy sources. That is a challenging goal, and we have made great progress by exploring early-stage R&D on advanced technologies that have the potential to reach our cost reduction goals.

Over the last four decades, DOE has demonstrated a proven track record in significantly reducing emissions from fossil fuel combustion, resulting in a cleaner environment for all Americans. The technologies developed through this R&D program are not only applicable to coal and natural gas-fired power plants, but can also be used with industrial sources such as refineries and steel, cement, chemical and ethanol plants. These technologies can be used to capture CO_2 directly from the atmosphere.

Funding provided by Congress through FE has resulted in commercial operation of the world's three largest CCUS demonstration projects in their respective industrial sectors (Petra Nova, Air Products, and Archer Daniels Midland). In total, these projects have captured, utilized, and stored almost 9 million metric tons of CO_2.

- Petra Nova: Retrofitted onto the existing W.A. Parish coal-fired unit 8, the 240-megawatt Petra Nova project near Houston, Texas, captures approximately 90 percent of the CO_2 from the unit's flue stream and permanently stores about 1.4 million metric tons of CO_2 per year for EOR in a depleted oil field approximately 80 miles away. As of March 2019, Petra Nova has captured and sent for storage over 2.4 million metric tons of CO_2, and West Ranch Oil Field has produced over 2.8 million barrels of oil through EOR.

- Air Products: The Air Products and Chemicals project at a petroleum refining facility in Port Arthur, Texas, captures over 90 percent of the CO_2 produced from the two steam methane reformers for hydrogen production. Air Products has successfully captured and stored over 5 million metric tons of CO_2 for EOR.

- Archer Daniels Midland: The Archer Daniels Midland Company project near Decatur, Illinois, demonstrates an integrated system for capturing CO_2 from an ethanol production plant and geologically sequestering it in the Mount Simon Sandstone formation – one of the largest saline reservoirs in the world for CO_2 storage. As of April 2019, 1.2 million metric tons of CO_2 have been injected into the Mount Simon Sandstone.

DOE's FY 2020 budget represents a purposeful shift away from later-stage R&D such as development and scale-up of 2nd generation capture technologies to prioritize early-stage

research and development to reflect the proper role of the Federal Government. Industry is better positioned to make decisions on what technologies can be commercialized and how to develop and scale these technologies for cost-competitive deployment.

One important element of FE's R&D effort is Direct Air Capture (DAC). FE was one of the co-funders of the recent National Academy of Sciences (NAS) report on developing a research agenda for negative emissions technologies, which included DAC. The focus of DAC R&D is on improving capture efficiency, reducing energy and capital costs (current cost estimates range between \$200–\$800/ton CO_2), and decreasing water resource demands. FE is conducting techno-economic analyses to establish a cost baseline for DAC technologies, and is funding exploratory research studies in this area. FE currently has three DAC R&D projects with:

1. Ohio State University – "Novel Carbon Dioxide (CO_2) – Selective Membranes for CO_2 Capture from less than 1% CO_2 Sources";
2. Carbon Engineering, Ltd. – "Dilute Source Carbon Dioxide (CO_2) Capture: Management of Atmospheric Coal-Produced Legacy Emissions"; and
3. InnoSepra, LLC – "Process for CO_2 Capture from Low Concentration Sources."

DAC technologies (e.g., advanced sorbents, membranes, and solvents) are built upon FE's R&D and are adapted to address issues specific to DAC, such as accelerating reaction kinetics. Existing resources in the FE program can be leveraged to develop new materials and design processes specific to DAC, optimize DAC performance using advanced supercomputers, and validate laboratory R&D through pilot-scale testing. FE takes a holistic approach to DAC-specific R&D by developing the technologies, system(s), logistics, and cost reductions to make DAC implementation a reality. Further, FE recognizes the important role that stakeholders play in this area and is planning a workshop later this year to strengthen that engagement. Low concentrations of CO_2 associated with DAC create unique challenges, but FE's 19-plus years of CO_2 capture expertise will help commercialize DAC.

In addition to DAC R&D, FE is also investigating ways to extract an economic benefit, or additional value, from the captured CO_2 through the development of products and services. For example, FE is working on CO_2 utilization as a feedstock for commonly used chemicals such as methanol, synthetic fuels, and baking soda, as well as advanced materials like improved concrete and carbon fiber. While EOR is the most near-term application of CO_2, the development of these advanced materials offers opportunities to monetize the captured CO_2 and drive domestic innovation.

In the area of Carbon Storage, DOE's goal is to better see the subsurface to improve site selection for geologic storage of CO2; improve CO2 storage and utilization efficiency for enhanced oil recovery; and increase the certainty of secure containment and environmental protection. Previous investments in an initiative called the Regional Carbon Sequestration Partnerships identified CO2 sources and sinks on a regional basis throughout the country and conducted large-scale injection projects. This resulted in over 10 million metric tons of CO2 stored. The work from this effort has been captured in Best Practice Manuals to disseminate that knowledge to industry partners.

Since 2016 DOE has invested over $70 million in the CarbonSAFE initiative, which builds on findings from pilot and field demonstration projects to advance site selection and storage operations at commercial-scale. There are currently six active CarbonSAFE projects regionally distributed throughout the US to determine the feasibility for commercial-scale storage complexes that can store greater than 50 million metric tons of CO2.

We appreciate the Committee's interest, support, and commitment to providing DOE with the tools necessary to advance CCUS technologies, and I look forward to answering any questions you may have.

Thank you.