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Good morning, Chairman Murkowski, Ranking Member Manchin, and members of the committee. My name is John Harju, and I am the Vice President for Strategic Partnerships at the University of North Dakota's Energy & Environmental Research Center (EERC). Thank you for the invitation to provide brief commentary today regarding the EERC's carbon capture, utilization, and storage (CCUS) activities that directly complement the provisions espoused in Senate Bill 1201, the Enhancing Fossil Fuel Energy Carbon Technology Act of 2019.

The EERC is a business unit of the University of North Dakota focused on practical solutions to our world's vexing energy and environmental challenges. The EERC was initially founded in 1951 as the Robertson Lignite Research Laboratory, under the U.S. Bureau of Mines. With the creation of the U.S. Department of Energy (DOE) in 1977, we became one of the nation's five energy technology centers and have been a part of the University since 1983. The EERC's mission has evolved considerably since that time, from a mission focused exclusively on the utilization of the low-rank coals that predominate our nation's resources west of the Mississippi River to a mission that focuses on all fossil fuels, as well as renewable and alternative fuels, and on attendant environmental challenges associated with their development and utilization.

In the arena of CCUS, the EERC has had the privilege of serving not only DOE, but also more than 100 nonfederal partners across the entire CCUS value chain. These projects have included everything from broad reconnaissance-level assessments of storage opportunities to detailed assessments of prospective storage reservoirs and field validation of ongoing CCUS projects; from cursory desktop evaluations of numerous capture technologies to pilot tests of many emerging capture techniques and ongoing field campaigns evaluating their performance for full-scale implementation; and from paper studies of new-generation platforms to pilot testing and demonstration-scale field evaluations. These projects have benefited from ongoing, robust financial support via DOE's Fossil Energy Program. Specifically, that support has spanned DOE's Advanced Energy Technology Program, Carbon Capture Program, Carbon Storage Program, and Storage Infrastructure Program.

In 2003, DOE released a solicitation for the establishment of a series of Regional Carbon Sequestration Partnerships to develop an inventory of our nation's major stationary CO_2 emission sources, as well as the attendant regional storage reservoirs, or "sinks." My team at the EERC was fortunate enough to be selected as one of the original seven partnerships in a region that ultimately spanned all or part of nine U.S. states and four Canadian provinces, which we refer to as the Plains CO_2 Reduction Partnership, or PCOR Partnership. What became apparent over the course of those earliest activities was that while our region has astounding potential for geologic CO_2 storage, our region's emissions are inextricably linked to our economic bases—from the mining, manufacturing, and industrial centers around the Great

Lakes and Mississippi River Valley; to the agribusinesses of Iowa, Minnesota, Nebraska, and the Dakotas; to the oil-, gas-, and coal-producing regions of North Dakota, Montana, Wyoming, and the Canadian provinces. Each of these distinct regions has an economic engine, and each of those economic engines represent the primary emission of CO_2. What also became apparent was that without the engagement of key stakeholders from within each of those economic bases, there was likely little opportunity to forge meaningful field evaluations of CCUS technology. A key partner offered that he does not see a carbon-constrained world, but rather a carbon-managed world. With that as a backdrop, we set out to find and develop those economically motivated carbon management opportunities. Today, the PCOR Partnership's membership reflects both ongoing and growing interest, with more than 120 strategic partners throughout our region.

A subsequent phase of effort spanned the years 2005–2008, and in that time frame the EERC was fortunate to have the opportunity to lead four discrete small-scale field experiments. The first was a terrestrial, or "indirect sequestration," effort in partnership with Ducks Unlimited and Ducks Unlimited Canada, wherein the carbon uptake of restored wetlands was validated and helped facilitate the monetization of carbon credits associated with wetland restoration. A second effort, in partnership with Apache Canada, validated the use of a CO_2–H_2S mixture from a nearby gas-processing facility as a working fluid for enhanced oil recovery (EOR) and attendant storage in Alberta's Zama Field. A third project evaluated the injection of CO_2 into North Dakota's most prolific conventional oil reservoir for EOR/CCUS. Finally, the fourth effort evaluated the injection of CO_2 into an unminable lignite seam to evaluate the potential for enhanced coalbed methane production and attendant CO_2 storage. As mentioned previously, each of these field experiments was inherently tied to a regionally significant economic engine and opportunity. And each of these field experiments substantially informed and guided our activities for the ensuing decade. Concurrent efforts of my team, in conjunction with numerous additional stakeholders led to North Dakota's development of comprehensive geologic storage rules for CO_2 that ultimately led to North Dakota being granted primacy for the U.S. Environmental Protection Agency's (EPA's) Class VI Program. As of today, North Dakota remains the only state with this primacy.

The most recent phase of our PCOR Partnership effort has focused on the full commercial-scale validation of EOR-related CO_2 storage at Denbury Resources' Bell Creek oil field in southeastern Montana. CO_2 is sourced from natural gas-processing facilities in Wyoming and transported via pipeline to the field. As of June 2018, the Bell Creek Field, had stored more than 5.9 million tons of CO_2, and an additional 5.6 million barrels of oil had been produced. At full fruition, the project is expected to produce up to 40 million barrels of oil and permanently store more than 15 million tons of CO_2.

Gas-processing facilities have represented "low-hanging fruit" in terms of regionally available CO_2, and at this point in time have minimal opportunity for expanded capture and use or storage in our region. Other regional low-hanging fruit is in the form of CO_2 from ethanol facilities, a by-product of the fermentation of corn. While only modest volumes of CO_2 are produced at each individual ethanol facility, that CO_2 is very pure and requires little processing

for reuse or geologic storage. The EERC has been fortunate to work closely with Red Trail Energy, a North Dakota-based ethanol producer, and we are proceeding toward field implementation of geologic storage of CO_2 proximal to Red Trail's facility. Aggregation of numerous ethanol facilities in other parts of the region also represents an opportunity for much larger storage or utilization projects.

Coal-fired power facilities represent the largest point sources of CO_2 emissions in our region and also represent some of the most difficult CO_2 to capture because of the dilute nature of CO_2 in the postcombustion flue gas and the complexity of other constituents in that flue gas stream. Our work via our Partnership for CO_2 Capture Program and subsequent efforts for technology developers, DOE, and utilities interested in the potential deployment of capture technologies have familiarized my team with most of the emerging CO_2 capture technologies that might be deployed on coal-fired facilities in the near future. In fact, my team has either performed developmental work or conducted pilot evaluations on most of these technologies. With that as a backdrop, the EERC began working in earnest with the development team for Project Tundra, led by Minnkota Power Cooperative. Project Tundra is currently working on a pre-FEED (front-end engineering and design) effort that will develop preliminary cost estimates for the deployment of a postcombustion capture system at the Minnkota-operated Milton R. Young facility near Center, North Dakota. The captured CO_2 will be used in regional oil fields for EOR and/or stored in a proximal saline formation. Project Tundra is an integrated CO_2 CCUS project that represents the next unit of scale-up from NRG's Petra Nova project, which you will also be hearing about today. Project Tundra also represents an important regional anchor for a DOE-sponsored CarbonSAFE effort that is evaluating the potential for the geologic storage of 50-plus million tons of CO_2 near the Milton R. Young plant.

The CarbonSAFE Program represents a key thrust of DOE's portfolio, namely the validation of large-scale geologic storage in saline formations. My team sees CarbonSAFE as complementary to the RCSP Program. While the RCSP Program focuses on developing compelling business cases for carbon utilization and management, the CarbonSAFE Program focuses on developing specific geologic storage sites of a minimum size and nature. In addition to leading the North Dakota CarbonSAFE effort, the EERC team has had the opportunity to also serve as a partner in additional CarbonSAFE investigations in Nebraska and Wyoming.

Finally, my team has had the opportunity to work on several elements of DOE's advanced technology portfolio, wherein next-generation energy production platforms are being developed that promise to revolutionize the way we generate energy and embrace the concomitant desire to manage CO_2. The most recent example of the EERC's work therein is our effort with 8 Rivers Capital, which is focused on developing a coal-fueled platform for the company's Allam Cycle, which you have also heard about today from Adam Goff.

None of this outstanding research and development work performed by the EERC would have been possible without the foresight of this key committee, your counterparts on the Appropriations Committee, and DOE. Senate Bill 1201 continues this critical recognition and support of the programs that drive our innovation. I am particularly pleased with the Bill's

recognition of the Regional Carbon Sequestration Partnerships. We are currently preparing a key proposal to DOE that would expand our region to include the key energy state of Alaska and to broaden our Wyoming engagement from just the Powder River Basin to include the entire state. With your direction and leadership, I believe that we are poised to continue our nation's progress toward broad, economically viable carbon management.

Thank you, again, Chairman Murkowski, Ranking Member Manchin, and members of the committee for your invitation to provide these remarks. I would be happy to answer any questions you might have regarding my testimony and my views on carbon management.