Testimony Submitted to the United States Senate Committee on Environment and Public Works

Energy and Environmental Innovation: Wyoming's Leadership in Using and Storing Carbon Dioxide Emissions

Submitted by Dr. Marcius Extavour, Executive Director, NRG COSIA Carbon XPRIZE

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Mister Chairman, members of the Committee, thank you for the opportunity to speak with you today about transforming carbon emissions from a liability into an asset. My name is Dr. Marcius Extavour, and I am the Executive Director of the NRG COSIA Carbon XPRIZE, a $20M global incentive prize competition to drive breakthrough solutions in converting carbon dioxide into useful products and materials. This role has allowed me to become immersed in the energy and carbon management innovation space in particular. The key point I would like to make today is that "carbontech" -- that is, technologies that can convert CO2 into products and materials -- is an important emerging technology sector that the State of Wyoming, the United States and the world can make use of to reduce the carbon intensity of our energy sector, fight climate change, and support long term economically and environmentally sustainable growth. The State of Wyoming is very well positioned to help drive the development, commercialization, and deployment of these solutions.

Carbon dioxide is usually thought of as a colorless odorless and relatively inert gas, a pollutant, or a greenhouse gas. However, it is not usually thought of as a valuable resource. In fact, it is. Our global economy today is fundamentally reliant on carbon-based materials, whether that's food, building materials, textiles, fuel, fertilizers and paints, and others. All of those materials can actually be manufactured using CO2 as a basic feedstock, as an alternative to fossil hydrocarbons, especially oil and gas. The science of converting carbon dioxide into other more valuable materials has been well understood for decades. The pathways usually involve biological conversion of CO2, harnessing what plants already know how to do; mineral conversion of CO2 into a more stable mineral, such as calcium carbonate, better known as chalk; or chemically, using electricity or heat to drive the conversion reaction. The science is well understood, and we know how to do it. The questions in carbontech today revolve more around engineering, business, and finance.

Carbontech presents an opportunity to generate revenue by harvesting a low-value carbon dioxide feedstock and transforming it into a high value product. This can actually create business opportunities out of reducing the carbon intensity of our energy and industrial sectors. The challenge is in making the technology efficient enough, and making materials that are valuable enough to be able to attract capital, drive down costs, and support scale-up and deployment. Innovation is the key that unlocks this puzzle.

The NRG COSIA Carbon XPRIZE is designed exactly to drive this kind of technology innovation. The mission of XPRIZE is focussed on catalyzing solutions to problems that

affect all of humanity, and whose solutions can create a future of abundance for all. We have created an opportunity for startups, university students, entrepreneurs and others from around the world to showcase their CO2 conversion solutions, and to compete for a share of the $20M prize. The prize launched in 2015, and is about to conclude in Spring of 2021, when we will announce the winners. After evaluating and testing dozens of technologies from around the world, we have narrowed down to 10 finalists. The ITC is the staging and testing ground for the finals of this competition, along with a parallel facility, the Alberta Carbon Conversion Technology Centre in Alberta, Canada. To win the prize, teams must demonstrate a small industrial demonstration plant, using flue gas from a power station as their CO2 supply. The ITC was designed to support exactly this kind of innovation, and the leadership of Governor Mead, Governor Gordon, and the Wyoming legislature have been instrumental in making this project a reality. I cannot stress enough how important the ITC has been and continues to be to the XPRIZE project. I also want to stress how incredibly audacious and demanding this challenge is -- to take a concept and scale it into a working industrial demonstration within just a few years. One of the Carbon XPRIZE finalists is operating at the ITC today, and I look forward to visiting with them after our proceedings today.

I mentioned earlier in my testimony that our economy is already reliant on carbon-based materials, like concrete, gasoline, plastic, synthetic textiles, and others. We do not typically think of these materials as carbon-based, but they are. Carbon-dioxide-based materials can take various forms. They can be fundamentally new materials that are barely in use today, like carbon nanotubes and carbon fiber. They can be better-performing versions of materials we are already familiar with, for instance lighter and stronger concrete, or biodegradable plastics. Or they can be exact replacements of materials we already use, the only difference being that they are made out of carbon dioxide instead of fossil hydrocarbons. Examples of this type include gasoline, diesel, jet fuel, methanol, formic acid, and many other industrial chemicals and materials.

We know that making industrial commodities like concrete, fuels and chemicals presents enormous business opportunities. A 2017 analysis by the independent nonprofit Carbon180 estimated a total addressable market of over $1 trillion dollars for CO2-based products, using only current and known technologies. A 2019 study in the journal Nature estimated break-even production costs of a range of CO2-based materials, and their capacity to actually use up CO2. The breakeven costs tend to be lower for lower-energy-intensity processes like making polymers, concrete, biochar, and methanol, and higher for higher-energy intensity materials like gasoline, diesel, and jet fuel. The study also estimated that each of the individual material types they considered could each scale up to absorb 0.5 billion tons of CO2 annually. Taken together, that means that CO2 materials could reasonably be expected to absorb around 20% of total global CO2 emissions, which is consistent with previous estimates. XPRIZE, ITC and many others are working on addressing the technical and economic barriers to realizing that possibility.

One of the most interesting and exciting developments in the space in the past two years is the emergence of consumer products, and consumer interest in products made out of CO2. The emerging market for consumer products introduces a new and powerful social

dimension, because it provides a way for regular people to participate in this space by buying everyday items that just happen to be made out of CO2. This is really a trend that emerged just in the last two years. It is important to note that the consumer products market is nowhere near large enough to absorb all the industrial CO2 being produced today. Instead, the opportunity here is that consumer products are a way to engage a much broader segment of the population in the conversion and movement around the transition to lower carbon intensities and sustainable growth in our energy sector.

I very much appreciate the opportunity to speak with you today, and look forward to any questions and discussion. Facilities like the ITC are essential for developing and scaling up industrial technologies like the ones we are discussing today, and Wyoming has a terrific opportunity to lead in this space by leveraging the ITC.