TRANSCRIPT OF PROCEEDINGS

In the Matter of:)
)
NATIONAL COAL COUNCIL)
MEETING)
)

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BEFORE THE UNITED STATES DEPARTMENT OF ENERGY
OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY

In the Matter of:)
)
NATIONAL COAL COUNCIL)
MEETING)
)

Marriott Wardman Park Hotel
2660 Woodley Road, N.W.
Washington, D.C.

Thursday,
September 12, 2019

The parties met, pursuant to the notice, at 8:30 a.m.

PARTICIPANTS:

TOM SARKUS
NCC Deputy Designated Federal Officer
Division Director, Major Projects Division
National Energy Technology Laboratory
U.S. Department of Energy

JANET GELLICI
Chief Executive Officer
National Coal Council

Legal Counsel:

FRED EAMES, Esquire
Hunton Andrews Kurth

KEYNOTE SPEAKER:

DR. BRIAN J. ANDERSON, Director
National Energy Technology Laboratories
U.S. Department of Energy

INDUSTRY KEYNOTE SPEAKER:

HAL QUINN, President and CEO
National Mining Association

PARTICIPANTS: (Cont'd.)

INDUSTRY PRESENTERS:

Developing & Commercializing Innovative Low Carbon Technologies:

HILLARY MOFFETT, Senior Director, Government Relations
Low Carbon Ventures, LLC

The Economic Case for Power Plant Carbon Capture Retrofits: A Case Study on the San Juan Generating Station - New Mexico:

JASON B. SELCH, CEO, Enchant Energy, LLC

NATE DUCKETT, Mayor, City of Farmington, New Mexico

Non-Energy Uses for Coal:

DR. IAN REID, Principal Associate
International Energy Agency, Clean Coal Centre

P R O C E E D I N G S

(8:30 a.m.)

MR. SARKUS: Good morning. We had an excellent dinner and speaker last night, and I know we're all eager to have a good meeting today. So I hereby call the fall 2019 meeting of the National Coal Council to order.

For 35 years, the National Coal Council has provided expert advice, counsel, and guidance on a broad range of coal-related policy issues, everything from technology to energy security. Representing the broad diversity of coal interests, the National Coal Council has always been counted on to provide solid, reliable, and balanced analyses and counsel. And because of that, you have earned the respect of the industry you represent and the policy makers you advise. You should be proud of your work. I know I'm proud to be associated with the Council.

Before we get started, I want to welcome National Energy Technology Laboratory, Brian Anderson, who will provide keynotes this morning, and National Mining Association and CEO, Hal Quinn, who will provide an industry keynote presentation. Thank you for joining us today.

Allison Mills, deputy director of the Office of Secretarial Boards and Councils is also here this morning, as is Fadi Shahid, senior economist with the Energy Information Administration. Thank you both for being here today.

I also want to acknowledge some of our leaders in the Office of Fossil Energy and NETL who have joined us this morning: Angelos Kokkinos, associate deputy assistant director for Clean Coal and Carbon Management, is here today, as is Doug Metheny, who splits his time as senior policy advisor to Assistant Secretary Winberg and to Secretary Perry.

From NETL, I especially want to welcome Director Brian Anderson. Joe Giovi has served as the deputy designated federal officer or DDFO for about the last two years and has done a tremendous job. Thank you, Joe. And thanks to NCC Chair Danny Gray and Vice Chair Randy Atkins for stepping up to serve the council in their respective leadership roles. And Janet Gellici, who works tirelessly on behalf of the NCC, as well as Hiranthie Stanford and all the others who have served to help the council function so well.

I want to thank all of the members and perspective members of the NCC for your service. And finally, I'm pleased -- are there any members of the public? If there are, I'm pleased to extend a welcome to you. I appreciate your interest in the topics that we will address today.

Before we move on, I wanted to call on NCC, Incorporated, Legal Counsel Fred Eames with Hunton Andrews Kurth to provide us with an important antitrust advisory that should be considered from the outset of our activities.

MR. EAMES: Thank you. As I'm sure you already know, meetings such as this involving competitors post antitrust risk. To assist the National Coal Council in both avoiding antitrust violations and preventing the appearance of a violation, we will abide by the following guidelines.

Do not in fact or appearance discuss or exchange information with actual or potential competitors regarding any of the following matters, either before, at, or after our National Coal Council-sponsored meeting or social gathering. Don't even joke about any of these topics. What you say in jest now may look very different on paper if you have to repeat the quote in a deposition.

The topics to avoid include prices, costs, margins, discounts, customers, and corporate plans. Unless the information is already public, don't talk about new products you plan to offer in the future.

Don't talk about products or services you plan to discontinue. Don't talk about the design, production, manufacture, distribution, or marketing of any products or services.

The U.S. Supreme Court has recognized that competitors can band together to attempt to influence legislative actions. Lower courts have extended this beyond legislation action to include efforts such as preparing joint presentations to influence other governmental agencies. This is called the Noerr Peddington Doctrine. Its bounds are somewhat uncertain and limited, however, and will not save you if you're fixing prices even in the context of this type of meeting.

If at any time you feel we've strayed from these guidelines, please interrupt the meeting. Thank you.

MR. SARKUS: Thank you, Fred.

This morning following Brian Anderson's keynote address and Hal Quinn's industry keynote, we'll get presentations on low-carbon technologies, a case study for retrofitting the San Juan Generating Station in New Mexico with carbon capture, and non-energy uses for coal.

Now, just a note. This meeting is being

held in accordance with the Federal Advisory Committee Act and the regulations that govern that act. A verbatim transcript of this meeting is being made. Therefore, it is important that you use the microphone when you wish to speak, and that you begin by stating your name and affiliation.

We will also have a public comment period at the end of the meeting to ensure that those not formally on the agenda are able to give their views. Having said that, I would like to welcome any guest from the public. I've already done that.

Council members have been provided with a copy of the agenda for today's meeting. I would appreciate having a motion for the adoption of the agenda. Moved and seconded. So thank you. The agenda is adopted.

So without further ado, let me hand the podium over to NCC Vice Chair Randy Atkins, who will introduce today's keynote speakers. Randy?

MR. ATKINS: Thank you, Tom. It gives me great pleasure this morning to introduce Brian Anderson. Brian is the director of the National Energy Technology Lab. As many of you know, the NETL is probably the nation's premiere research lab in the field of fossil energy.

Brian has been awarded the honor achievement award from the DOE for his role on the team that responded to the Deepwater Horizon oil spill. He's a recipient of the Presidential Early Career Award for Science and Engineering. Brian earned his undergraduate degree at WBU in chemical engineering, and then went on to receive both his master's and PhD at MIT.

It gives me great pleasure to introduce Brian, who is one of our nation's leaders in energy research. Thank you.

(Applause.)

DR. ANDERSON: Randy, thank you, and I really thank the National Coal Council for this opportunity to speak a little bit about what we're trying to do at NETL in terms of moving technologies forward. These are necessary technologies for the pathway of the energy sector for not just the United States, but the globe.

Just as a testimony to what we're trying to achieve at NETL, two weeks ago, we hosted our annual program review for carbon capture utilization and sequestration. And because we identify some crosscutting areas in the subsurface, we also included the oil and gas program.

This particular meeting in Pittsburgh had 581 attendees from a dozen or so countries, and certainly across the United States, and was a week long I guess parting, in terms of technologies and the ways the technologies are moving forward.

At the end of that meeting, we had a bilateral with the country of Norway where they are leading efforts in the European Union for carbon sequestration. It is starting to become very clear internationally, and maybe even less so nationally, that the technology solutions for fossil energy electricity generation is not only necessary, but is imperative for the future of fossil energy globally.

Under the context of restrictions of CO_2 emissions and the context of the global marketplace for further deployment of energy across the planet, we cannot achieve these two goals of electrifying and providing low-cost energy to 7 billion, possibly soon to be 10 billion, people on the planet without fossil fuels in the mix. And if we put the restriction of carbon emissions along with that, we cannot achieve those two goals without the technologies that we're trying to advance at NETL.

And so I've been at NETL now 10 months as of yesterday, not that anybody is counting. But it's amazing what I've learned about this organization and what I am excited about our future that I have been able to see since becoming director.

I want to highlight a couple of technologies here, even on the title slide, in that we're trying to advance technologies in gasification all the way from particle models up to large-scale gasifiers for one example of advanced energy systems that can help move technologies forward.

And then what you can't really see, on the right side, the one that's illuminated by some nice, pretty blue light, as we like to take pictures in the lab with blue lights, is our technology advances in developing single crystal sapphire fibers that are long enough to create fiberoptic cables for intense environments. And imagine using distributed temperature sensors using sapphire optical fibers in a boiler to better understand and characterize what our temperatures are within a coal boiler. And we have the record at NETL for the longest continuous single crystal sapphire fiber manufactured in the world for this technology.

I need to now find out how to advance the slides. Which button?

AUDIENCE MEMBER: The middle button.

DR. ANDERSON: No.

AUDIENCE MEMBER: All right. The on-off switch on the side.

DR. ANDERSON: That will do it. That tells you how long I talk when the title slide doesn't --

So according to our mission at NETL is to discover, integrate, and mature technologies to move them on to the market. So we're working on discovery technologies or discovery science, all the way through integrating scientific progress together into coherent systems and then trying to move them to market. And this is -- I don't want this to be lost on this audience or even the people at NETL because our job as a unique government-owned, government-operated laboratory among the 17 national labs is not only to work hand in hand with the Office of Fossil Energy in designing and developing the technology pathways for fossil energy, managing the program portfolio, and then integrating technologies together across the entire portfolio, and with what we do inhouse at NETL.

But ultimately, every technology pathway that we're developing is trying to get into the market, trying to get it into your hands so we can deploy it further. And so I always want to start with the context of that mission at NETL.

So we are part of the national laboratory system. I mentioned we're the only government-owned, government-operated laboratory, which means that we have a unique role among these 17.

And I appreciate your comments, Randy, about us being the renowned fossil energy laboratory, and we work hand in hand with our partners. But we do think we play a very unique role by our nature of our relationship working with fossil energy, and then trying to deploy the technologies.

And so as a snapshot, we have our three physical laboratories in Pittsburgh, Pennsylvania and Morgantown, West Virginia, and Albany, Oregon. But the key thing is that we are working hand in hand with project partners that number greater than 600 project partners across the country and across the globe on 900 different projects, with a total value currently today of over $6 billion and annually about a billion dollars of annual research expenditures, because we're all trying to push forward that mission of how we can develop the technologies that are necessary to ensure that dual challenge is met, deploying clean, low-cost energy to the 7 billion people on the planet, and the 300 -- and soon to be 350 million -- people in the United States, and doing it in an environmentally responsible manner.

And so it takes a village. It takes a great partnership to be developed between NETL and our project partners.

I keep hitting the wrong direction.

So at NETL, inhouse research, we divide up our technical skills into five technical skill sets called core competency areas, and we apply these across the program areas, not just in fossil energy and coal, oil, and natural gas, but support to other DOE program offices, including -- I will highlight -- the Office of Energy Efficiency and Renewable Energy, the Office of Electricity, and the Cyber Security, Energy Security, and Emergency Response.

We're trying to take it upon ourselves to understand the entirety of the electricity system so that we can fully realize our potential to draw down costs, meet environmental challenges, and make sure that all of the technologies that are being deployed on the grid are integrating in the most efficient way possible. And we're seeing the effect of cycling on our power plants in the existing fleet, and we're seeing the effects on the grid of increased variable renewables and potential reliability issues.

And so we work in computational science and engineering, everything from the molecular scale through large-scale simulation. We are home to the largest public super computer dedicated to fossil energy that is not in the private hands, in the private sector hands.

It is the 23rd -- well, actually now 21st -- fastest super computer in the United States solely dedicated to fossil energy research.

We also have a vast effort in material science and how we can advance new materials, new alloys, and not just computationally, but all the way through our alloying and manufacturing facility in our Albany lab site. And the geologic and environmental systems area specific to the coal sector, we are trying to understand processes in the subsurface that occur when we sequester carbon dioxide, but also leverage our understanding of the subsurface that we're gaining from the oil and gas sector, the vast troves of exabytes of data that are coming from the oil and gas sector, of understanding the processes in the subsurface and how we can apply them to reduce risk in carbon sequestration.

And so we have an initiative, a new initiative in this space in machine learning and artificial intelligence that was highlighted by the secretary just last Friday with the establishment of the Artificial Intelligence Technology Office within the Department of Energy and highlighting NETL's work in this space.

In energy conversion engineering, this a new processes, such as pressurized oxy combustion and chemical looping combustion, as well as advanced turbines that we have been working with industry to develop over the years. And then finally in systems engineering and analysis so we can understand the techno-economic context in which technologies are going to be developed, so we can find the appropriate technology pathways into the commercial space, as well as understanding the life cycle assessment footprint of these technologies.

And last and certainly not least is how we integrate projects through our program execution and integration core competency of how we understand what is going on in 900 different projects, and try to work hand in hand with the Office of Fossil Energy to push forward these technologies.

So if you want to see NETL in one slide, it's right here. Specific to new coal technologies that we're working with, with the Office of Fossil Energy, if you break down the categories according to our congressional appropriations, in advanced energy systems, this is specifically how we can move forward new technologies for the existing fleet, as well as through the Coal FIRST program that Steve Winberg spoke to this group about in April, and how we can advance these technologies down the economic pathway into commercialization. And crosscutting research, this is where our materials work as well as computational work falls in, in step that many of you are familiar with, the super critical technologies for CO_2, super critical CO_2 as advanced power cycle with higher efficiency than using steam.

And then a lot of effort in carbon capture utilization and sequestration. And I'll speak to some of the challenges on the next slide for that. And then certainly in transformational coal pile is how we can move technologies into the market.

So the evolving topics that we see in the coal sector from a research standpoint at NETL is how we can upgrade the existing fleet through retrofits and providing efficiency enhancements, reliability enhancements, and the ability to stave off the unplanned maintenance that might come with cycling, that follows on with the load following that we're increasingly seeing our existing fleet have to manage.

The second is advancing the next generation of power plants. And certainly our Coal FIRST program is the highlight of this, and I would be remiss to not say that, actually, if you want to hear about Coal FIRST, catch Angelos Kokkinos at a break. He would be more of an expert than I am.

However, we are really excited about this opportunity internally at NETL to get technologies into integrated systems that meet the Coal FIRST standards of flexible, innovative, resilient, small, and transformative.

The next area that I know that is of great interest, and I do have to give the thanks to the National Coal Council for the reports on new uses of coal, because this is an area of great interest to us to provide additional markets and value for our coal resource.

I am a chemical engineer by training and by nature, and it has always bothered me to take such a great, wonderful, complex molecule, set of molecules, that we have in our coals and in our oils and gases, and take them and destroy all of the exergy in them, all of the entropy to burn down into the lowest form of products.

So there we have a rich trove of complex molecules that have a tremendous pathway into a higher value-added marketplace. And so for our economies, like in my home state of West Virginia and Kentucky and Pennsylvania and Wyoming and North Dakota and Montana, for those economies to have opportunities to provide value addition from those raw materials is tremendously exciting.

And so this is an area of great interest, great personal interest, to me because perhaps we cannot replace coal ton for ton, but maybe we can job for job through value addition, through advanced manufacturing techniques. And so this is a tremendous opportunity for future of economies of coal states and coal communities that I see.

The next big challenge is how we can reduce the cost of carbon capture. The 2015 report out of NETL showed that more than 63 percent of the cost of carbon capture and utilization was just simply in capturing the carbon, not in compression and in the long-term stewardship of a sequestered CO_2 molecule.

But if we can use all of the tools that are at our disposal -- and I'm showing here an advanced manufactured material for -- advanced packing material for carbon capture systems that can be designed straight from the computer, can then be 3D printed and put as a packed bed that can increase the heat transfer out to the system, that can increase the mass transfer into the solvents or absorbents in some cases to make the carbon capture system more efficient. And I'll also speak to some of our working members.

And then last and certainly not least in the evolving topics in coal, is how we can reduce the water footprint, water consumption, fresh water consumption from our energy production writ large. This is increasingly becoming one of the tremendous interests in the U.S. and across the globe that the food, water, and energy nexus that we need to reduce our consumption of water.

So I'm going to fly through a bunch of interesting technologies, at least interesting to a techno geek like me that we're working on at the National Energy Technology Labs, specifically upgrading the existing fleet of focus areas, and how we can design and deploy new sensor technologies to understand the processes that are going on as well as be able to predict preventive maintenance, opportunities so that we can avoid unplanned shutdowns of our existing fleet.

And I've already highlighted a little bit the sapphire optical fiber opportunities in that extreme environment to provide high resolution temperature management within a boiler. And so not only are we working inhouse, but our project partners like at Virginia Tech has moved this technology from a TRL-1 to a TRL-7 under our portfolio so that we can start to be able to deploy this distributed temperature sensor.

In the extreme materials example, we are leading an effort across multiple national labs in extreme materials. How we can start from computation and predictive modeling all the way through producing new materials that can withstand the extreme environments that we're seeing, not only the existing fleet, but in the potential future fleet for coal. And so we see a tremendous opportunity to be able to advance new materials into the market with this holistic approach for extreme materials.

When it comes to the next generation power plant, we're focusing on modular power plant technologies you see under the Coal FIRST, more toward that smaller end of the 50-megawatt or 100-megawatt size, and then how we can ensure stable power generation, but is also flexible and efficient even at extremely low turndown rates.

And one example project in our extramural portfolio is not just an advancing new technologies, but then understanding how the supply chain can be built so these technologies can in fact go to market. And so we have the project in the advanced ultra-super-critical technology program called the Comtest (phonetic) Project, where the industry partners are developing and modeling what the supply chain would look like, in order to not only be able to manufacture the components using advanced materials, but ensure that that supply chain is efficient and economical.

So we've already highlighted on Coal FIRST the flexible, innovative, resilient, small, and transformative power plants of the future. And this is certainly a highlight of the Office of Fossil Energy and something we see not only as an opportunity for market building in the United States, but a potential market across developing countries across the globe.

We have tremendous interest from international partners that we are seeing in this program as they are watching the United States develop these technologies, then potentially having our ability to export to existing world markets.

And then on that topic of pioneering new markets for coal, some of our focus areas specifically are in converting coal into higher value materials, like I had mentioned, as well as evaluating the cost and performance of these coal-derived materials to their competitors on the market.

Some examples include carbon fibers as well as electronically conductive principal inks for the electronics manufacturing, as well as quantum dots. And in the carbon fiber area, I want to highlight that there are new technologies coming on the market for advanced manufacturing using composite materials. This was mentioned last night, the trend in D.C. of refinishing your cement floor in your garage. Well, this goes well beyond that.

We think of our aging infrastructure in the transportation sector across the United States. Even in Pennsylvania and West Virginia combined, there is about 12,000 bridges that need revitalization because of their age and their ability to bear weight.

Carbon fiber-reinforced plastic produces an opportunity to provide new bridge decking, new road decking, supports for bridge resurfacing with a material that is not conducive to corrosion, and also can be lighter than steel and even stronger.

Now, if we end up developing this market, we need the right raw materials to feed and create those carbon fibers, and coal presents a tremendous opportunity for that value addition. So it's not just for our golf clubs and our bicycles.

In the area of rare earth, which certainly is of great attention nationally, internationally, and I'm certain in this room, internally at NETL we are developing great technology for the separation and identification of rare earths, everything from ash piles to coal refuse piles, as well as acid mine draining sludge. And our extramural partners like at the University of Kentucky and PSI and West Virginia University, are doing a tremendous job of advancing these technologies toward the commercialization.

Other areas in high-value products, I've already mentioned some of these, but also graphing-enhanced cement. And we can imagine this is also not only high value, but also high volume. And then one of our project performers is developing flame-resistant, lightweight roofing tiles potentially to replace asphalt tiles, and seeing tremendous opportunities in that space.

So then how can we reduce the cost of carbon capture? We need to hit $30 per ton of CO_2 capture in order to make it economical. And we know that the 45Q presents a tremendous opportunity, and we're well aware of the sunsetting date and the constraints that that puts on the private sector.

Just this week, and today, as a matter of fact, in Chicago the Oil and Gas Climate Initiative is meeting and entertaining pitches from companies who are developing carbon capture and carbon sequestration and carbon utilization technologies to try to move them into the market. There is a tremendous interest, not just from the coal sector, but from oil and gas, in moving these technologies forward.

And so I would encourage the coal sector to work hand in hand with oil and gas and the chemical sector to keep moving these projects forward. One example that I would give of the interest of the private sector in oil and gas is the MOU that we signed earlier this year with Exxon Mobil. And I use the wrong word. It was not an MOU. It was a series of five different agreements plus an agreement for commercializing technology, including two CRADAs, two IP agreements, umbrella charter between the National Energy Technology Laboratory and the National Renewable Energy Laboratory, with Exxon Mobil.

It was a 10-year, $100 million to take technologies for carbon capture utilization and storage and move them to scale and then to the market.

So they are in fact -- they being the oil and gas sector -- are in fact putting the money where their mouth is in terms of trying to develop these technologies hand in hand with the coal sector. And so I see tremendous potential to move these forward.

And then I can't help but highlight some of our experts at NETL in developing new materials for carbon capture. This example uses our super computer Jewel (phonetic) to screen over a million different combinations of polymers and molecular organic framework molecules to create a composite membrane for the separation of CO_2. And over screening these million different molecules, they identified two combinations that would dramatically decrease the cost of carbon capture down to about $45 a ton from 55 at the initial start of the screening.

That advancement screened a million different combinations, but there is about a billion in total. And so we're now incorporating artificial intelligence and machine learning techniques to understand the physical fundamentals of what made those two combinations stand out of the other -- the rest of that million.

So instead of screening another 999 million, we're able to understand and learn from the computer with this vast amount of data how we can screen another million and make some more advances.

And then I've already highlighted a little bit in additive manufacturing how we can use all the tools at our disposal to significantly decrease the cost of carbon capture to make it commercial on its own and/or with 45Q.

And then our last area in reducing -- I'm probably running short on time. How much time do I have?

FEMALE VOICE: Ten minutes.

DR. ANDERSON: Oh, great. Okay. Well, I'll slow down even.

(Laughter.)

FEMALE VOICE: Take a breath.

DR. ANDERSON: Well, no. That's fine. No, I don't usually take a breath, so this will leave some time for questions potentially.

So in the area of reducing water, I've mentioned in the United States we have tremendous areas of water stress. And so if we can not only improve the efficiency of a power plant, if you know the first and second laws of thermodynamics, you know the more efficient you are, the more heat you're rejecting.

And so first, the efficiency helps in our water usage, but also the ability to provide hybrid cooling and even dry cooling at high efficiency are areas of tremendous interest, as well as water reuse and treatment.

We've made tremendous advances in the oil and gas sector for the treatment of flow-back in produced water in oil and gas. In the Appalachian Basin, in the origins of the shell gas revolution from 2005 to about 2010, we're putting so much briny water into the systems and into water treatment plants that you could detect the total dissolved solids all the way from Morgantown to Pittsburgh up the Monongahala River, so much so that there were public water treatment systems that were already above their TDS level when they were at their intake of water treatment.

And so this presented a tremendous problem. And so NETL and the industry worked together, the Marcellus Shell Coalition and others, to tackle that problem. And today, about 90 percent of the water, flow-back and produced water, that are in the Appalachian Basin is reused, treated and reused within the basin.

Because of the nature of the plan, it's a little bit different, but when presented with a challenge like the dual challenge of how we're going to reduce -- how we're going to provide low-cost electricity, low-cost energy to the planet, but also reduce our carbon footprint, we are trying to step up and meet that challenge.

And I always go back to the Clean Air Act. When presented with the challenge where the enemy was SOx emissions and NOx emissions, then enemy was acid rain and smog. NETL and the industry stepped up to that challenge and cleaned up our emissions, and also particulates. I can't leave that out.

And so if the enemy today is global warming and CO_2, then I think we can step up to that challenge. And in this case, in water reduction, if the enemy is using too much of our fresh water resource, which is extremely valuable, we're going to find technology solutions to achieve that.

And so at NETL we mentioned in terms of our mission is to discover, integrate, and mature technologies to where we can hand them off to the industry and to the commercial space. This is presented in this chart.

I think the appropriate place for academia, the national labs, and industry to work on technology development -- we have tremendous scientists and a tremendous cadre of ideas across academia, as well as in the private sector in research shops at the TRL level one. These ideas as they come to fruition, it is the Department of Energy, the Office of Fossil Energy's purview to take these ideas and to try to move them along the technology development pathway from discovery toward system integration and testing to demonstration.

But ultimately, we do a lot of analysis to identify that technology pathway and where it fits into the commercial sector, so that we know the appropriate portfolio that we would want to work on. Our appropriated budget is -- you know, we've seen a couple of years of good appropriations for fossil energy research and development. But it's not an unlimited source of funds. And so we have to make hard decisions on technology pathways, and we work hand in hand again with the Office of Fossil Energy and the rest of the Department of Energy, to clearly identify technology pathways through a set of strategic planning, strategic visioning, as well as a technology pathway development. And so we are all trying to point toward how we get these to market.

And so, of course, one tremendous example in technologies that moved from TLR-1 of just solvents that absorb CO_2 all the way to full-scale commercial deployment at Petra Nova. This took about 25 years, which actually on the commercial development time scale isn't horrible.

And so this is a tremendous example of getting things into the market. However, one of the big areas of focus for us is shortening this time line. And we can do that through computation. We can do that through predictive modeling and an appropriate portfolio of deployment testing, pilot scale, and deployment. And this is absolutely our goal.

So I solicit your feedback on how we can better create this pathway from discovery into commercialization, because you in this room are on the forefront of moving technologies in the markets. And so I appreciate any feedback that we can get.

So certainly we don't do this alone. We have, as I mentioned, about 600 different partnerships and 900 different projects we're working on that span the entire sector of small, medium-sized business, large business, academia, the public and private sector, other government agencies. And so, you know, when I think of NETL, I think of the way that we can partner in many different ways.

And so we have an entire toolbox of how we can partner. I mentioned with Exxon Mobil we have a cooperative research and development agreement as well as intellectual property agreements. And cooperative research and development agreements are ones in which joint partners with a common vision for moving research and technology forward can work hand in hand, can work shoulder to shoulder, where under a CRADA agreement, researchers and external partners can come to NETL and work with our researchers, or vice versa.

And so I'll give Exxon Mobil as that model. Just tomorrow we're having a workshop with them, on how their scientists working on the subsurface can work with ours and push forward advances in understanding subsurface processes through machine learning and artificial intelligence.

And so when we enter CRADAs, that's an opportunity for us to get our hands dirty hand in hand together and shoulder to shoulder in the laboratory and work together. Of course, many of you are familiar with the FOA process, the funding opportunity announcements, and grants and contracts and cooperative agreements, the way that we fund under the federal procurement. But that's what makes NETL unique, I that we have those in our toolbox to be able to enter cooperative agreements, where we provide federal funding to co-development technologies, as well as within our portfolio, the whole suite of partnerships through memoranda of understanding CRADAs to use our researchers to help move technologies forward hand in hand with you.

And so I really thank you for this opportunity to speak a little bit about a place that I love. I may have only spent 10 months there, but I've been a partner with NETL for over 15 years. And so I'm proud to be there at NETL.

So I did I leave any time for questions, or did I fill it up? All right. Thanks, Janet.

MS. GELLICI: -- the mic. So please join me in thanking Brian for his presentation.

(Applause.)

MS. GELLICI: Your enthusiasm and energy come through very strongly, so thank you so much.

Questions for Brian? I'll start while you're thinking.

The R in Coal FIRST, the resilience area, are there technologies there that you're looking at, or are there approaches? Can you talk about that activity?

DR. ANDERSON: Yes. So our systems

engineering and analysis group, as many of you may have seen, did a report on the bomb cyclone that was released last year. And so we from the top level are trying to identify and even define what resilience would mean, per our conversation last night with the chair of FERC.

So first we're starting at that top level of understanding markets and grids and how the energy is distributed, as well as the potential effects of retirements in the future. There are some opportunities that we're working on in terms of technologies that includes electricity and energy storage. We're also partnered with our two sister energy laboratories, the Idaho National Laboratory, our nuclear laboratory, and the National Renewable Energy Laboratory, NREL, on an effort that we're calling the tri-lab effort, specifically targeted at the interface of all of our electricity-generating capabilities on the grid, and how we can develop integrated systems that are even more resilient.

Now, certainly through the Coal FIRST we are pushing our partners to design within the boundaries of one plant the opportunity to be resilient, to also -- well, I guess to be more reliable and more flexible. But I guess those are our efforts on a top level with the grid as a whole, as well as hybrid technologies at the interface of fossil, renewable, and nuclear.

MS. GELLICI: Thank you.

Questions? And if you'll state your name and affiliation.

MS. POTTER: Good morning. Ellie Potter, S&P Global. I wanted to see if you could -- if you're able to speak to this outline, a time line for when these Coal FIRST power plants may be commercialized, as well as carbon fibers and -- sorry -- carbon capture technology. Thank you.

DR. ANDERSON: Yes. So for the Coal FIRST, we're looking for the first Coal FIRST pilots in three years?

AUDIENCE MEMBER: Around 2025.

DR. ANDERSON: Around 2025, yeah, sorry, yeah, for the first -- for the pilot-scale demonstration of Coal FIRST around 2025. Incidentally, in terms of carbon capture technologies, we're looking for the next generation of carbon capture to be into the commercial sector also at 2025. And then finally, the further on next generation innovative carbon capture technologies in 2035. And so those are the time lines that we have set out, and there are congressional time lines along with that, too.

MS. GELLICI: And one final question then I'll ask for your advice. We get a number of calls into our office on a fairly regular basis from folks that have a good idea or a new idea, and it always amazes me that people, the entrepreneurs with different technologies, and there is a sense of frustration in how do we test these technologies, where can we go to get that done.

Can you talk a little bit -- I know your prior life was at West Virginia University. Are the universities an option? You know, you've spoken a little bit about what is available at NETL. But is there any advice you can offer to some of these folks who are working on these things?

DR. ANDERSON: So there is no one-stop shop. And I think that's what makes things often difficult. You know, I think that, you know, they can contact us at NETL, and we can point them in the right direction. If it's a carbon-capture technology, the National Carbon Capture Center and the Integrated Test Center are great opportunities in the United States, as well as, you know, some internationally for testing new technologies for carbon capture, as one example.

And it depends on the scale. If it's bench scale, many of the universities have the capabilities in their laboratories. And so there is no one place. I offer NETL perhaps as a place we could point them in the right direction, whether it's us or somebody else.

MS. GELLICI: I guess the good news is that those ideas continue to flow. So thank you very much, Brian. I appreciate all your efforts.

DR. ANDERSON: Thank you, Janet.

MS. GELLICI: Thank you.

(Applause.)

MR. ATKINS: Great. Thank you, Brian, for your remarks. And I would also like to thank you for your shout-out on coal to products. I would echo that we have been one of the proud partners with NETL for about the last year and a half on a CRADA, and I can recommend NETL to anybody who is interested in the research area.

So at this point, it gives me great pleasure to introduce my friend, Hal Quinn. Many of you already know Hal. For many years Hal was the president and CEO of the National Mining Association. In that role, he has touched virtually every regulatory, legislative, or governmental aspect of the

U.S. mining industry, including coal, minerals, metals, agricultural minerals, equipment manufacturing, basically I think anything that comes out of the ground that you don't eat.

And I would like Hal to know that we are now working on using coal to perhaps come up with some forms of fertilizer. So you may get into the food business after all.

So before Hal held his position as the head of the National Mining Association, he basically held the roles of executive VP and counsel to the NMA. And before there was a NMA, he was the head of the National Coal Association. Hal serves on the International Energy Agency's coal advisory board, on the board of directors of the U.S. Energy Association, and the National Energy Foundation.

He's a member of the Society of Mining, Metallurgy and Exploration. Hal received his undergraduate degree at Denison, and his law degree from Wake Forest. Please welcome Hal Quinn, who is definitely a friend of coal.

(Applause.)

MR. QUINN: Good morning, members of the council and their guests. And, Randy, thank you for that invitation. Janet, thanks for the invitation.

Randy, I meant the introduction.

Actually, I was not the head of the National Coal Association. One of my mentors, General Richard Lawson, that many of you might remember, he was the last head of the Coal Association before we put the merger together. And I know he was a big fan, as I am, of the work of the Coal Council, and was often a guest in this group.

So when I was getting prepared for today, I thought it may be a little bit of a retrospective of, you know, where we've been as an industry, is in order so we can maybe assess what the future could look like. Brian, your remarks are ones that continue to provide me great optimism for our industry in knowing that we have the partners we have at DOE and the labs and so forth.

So when I first arrived, I guess as we would say, in the coal about 40 years ago, you know, the nation was grappling on how it was to position itself for the future, with an anticipated era of energy scarcity. Natural gas had basically been deemed a depleted resource in this country. Oil was subject to the whims of various cartels posing various geopolitical risks. Wind and solar at scale were probably still a glint in the eye of some dreamers.

And the anointed energy savers were essentially coal and nuclear.

They were viewed as virtually inexhaustible. They were going to power the country. Coal was going to do double duty by providing us synthetic fuels and feedstock. But much has changed, as we know, today. We've really gone from a crisis of energy scarcity to an orgy of energy abundance, at least in my opinion.

The U.S. now, we're the top oil producer, producing so much natural gas we're either burning it off or paying people to take it off our hands. So in a lot of ways, we're really seeing the two faces of energy abundance.

Mae West was famously quoted as -- one saying is too much of something good can be just wonderful. Well, she was obviously speaking from the perspective of a consumer of good things, but if you're actually a producer of good things, abundance can be downright miserable.

You know, coal has been really served up as exhibit A for that particular metaphor. But I think we're now seeing the misery of energy abundance spread beyond coal. So oftentimes we'll see in the headlines is a spate of coal bankruptcies. But if you look below the fold, there is a surge of bankruptcies arising in the oil and gas industry as it becomes somewhat of a victim of its own success. Even their lenders, their shareholders are calling for disciplining capital allocation, and clearly production at this point in time.

Well, to add to these woes, we can look at the demonization of fossil fuels in various quarters, including some aspiring presidential candidates. You know, one recently called fossil fuel production a criminal enterprise. Now, think about that. Eighty percent of the energy that has raised the standard of living in this country for over a century has been dubbed a criminal enterprise.

I suppose that's just a bizarre affirmation for that sardonic saying that no good deed ever goes unpunished. And we'll see how that proceeds.

But this is really in a lot of ways -- these are the market realities and the political dynamics, at least for the moment. And I will emphasize the word moment. Past predictions and forecasts have proven awfully consistent, off the mark, and more than occasionally.

So as we look ahead, I think we still confront some prospects here and challenges. And I think what really the questions that present in our coal industry is really all about adaptation. And, you know, how do we cope? Is the coal industry able to adapt to cope with these confluence of events of producing this particular situation, and then how do we prepare ourselves for the future.

Now, as I look back, I mean, coal's story has always been about adaptation. Before electricity became coal's dominant market, it was really the industrial and transportation sectors that were the primary consumers of the product. For the better part of about 20 years, between 1950 and '70, coal consumption was running at or below half a billion tons annually. And coal's growth in the electricity sector at that time was really simply offsetting deterioration we were seeing in other markets.

You all know the story about coal since then. Electricity demand and its use has really been -- dominated coal's story since that time. Generation, coal generation, doubled over two decades, and at one time approached almost 60 percent of electricity generation in this country.

And here is something a lot of folks often forget about, is that, you know, when coal punched through the one billion-ton production mark, probably back in 1990, it stayed in that range for over a quarter century. And it did so while all the while producing more with less. You know, sustaining that type of performance, producing 75 percent -- 60 percent more coal from 75 percent fewer mines in my view is one of the most remarkable stories in the annals of industrial productivity that is often overlooked.

So now we face an entirely different situation, as you all know. Electricity generation hasn't grown in a decade, has never recovered to its pre-recession levels. Low growth means that new capacity additions are cannibilizing the incumbent resources. State policies have increasingly crowded out coal by setting aside market share for politically favored resources. And, frankly, competing resources have lowered their cost, while aggressive regulations and an aging fleet have really increased the going-forward costs for most coal plants in this country.

So I think all three observations about all that would be that market fundamentals matter, public policy can shape markets, but over the longer term, it's technology and innovation that is largely going to dictate participation in those markets.

So with that in mind, I think I'll just provide you some observations about maybe what is the next chapter for coal. What opportunities may present themselves, and are we going to be able to adapt to seize them?

We'll start with electricity. As I see it, we neither wait for a black swan event in energy, in electricity, in the hopes that somehow reaffirms the inherent value of coal-based load to the grid. Or we can lean forward to advanced technologies that are positioned as to compete. And whatever anxieties -- and they are much out there in terms of the current industry situation -- whatever they may be, they ought to serve as a motivator, and not as a fuel for fear of a technology or the solutions that are going to require us to change our business models.

Intuitively, as I see it at least, the more -- or as did dispatchable resources exit the market today, the more valuable the remaining ones will be tomorrow. Our new and existing -- as Brian mentioned, new and existing dispatchable resources will need to be more flexible to deliver their enhanced value to a cost effective power system, offering key attributes of optionability, reliability, and fuel security.

For new coal, I think that challenge will be commercializing technology to make coal plants a better fit for the evolving grid profiles as we experience deeper penetration of variable resources. This means higher efficiencies, higher ramp rates, lower minimum loads, in short, stable power with operational flexibility, much of what Brian was describing to us just a moment ago.

Now, in the meantime, I think existing plants can enhance their value of life with steam cycle efficiency improvements, greater recycling of waste heat, and smart controls for optimal system performance during more frequent deep cycling.

And finally, I think we cannot ignore the demand, the growing demand, for lower carbon profiles on the grid. So the improvements we make with existing efficiency and flexibility, they'll pay near-term dividends with lower emissions, but at the same time, build a foundation for eventually pairing those plants with carbon mitigation technologies.

Technology is just one piece of the roadmap. We also need public policy and market reforms to support us throughout this journey. In some respects, the recent initiatives of the Trump administration provide some welcome relief from regulatory assaults of the recent past.

The repeal of the Clean Power Plant and the proposed Matz finding that existing standards are sufficiently protective, should provide greater regulatory comfort about the prospects of more regulatory-induced costs that have contributed to the marginalization of coal plants.

Resource review reform, namely, replacing the annual emissions test with a narrowly emissions rate test, would finally remove the perverse longstanding and perverse regulatory barrier to deployment of the technologies that make plants more efficient and flexible.

On wholesale market design, if anything emerged from DOE's unsuccessful grid resilience pricing proposal, it was the big reveal that wholesale markets are not truly competitive at the classic sense at all. Modern state policies that initially intended to kickstart emerging variable resources are now becoming epidemic and infecting wholesale markets. They're proliferating in number and scope, and are spawning counter measures to really offset what the resources they were disadvantaging in the first place.

So all this spreading infection has forced FERC to assess the threat these policies pose to the integrity of market designs as well as grid resiliency. Depending -- PGM minimum offer price rule is a good start in addressing the price suppression resulting from the rise of out-of-market support for selected resources.

So while we're on the topic of public support, perhaps the phaseout of the federal tax preferences for wind and solar provides an opportunity for a policy shift toward supporting dispatchable resources. The wind PTC has existed for almost four decades, and long after renewables have declared that they would reach grid parity with fossil fuel resources. The growing mismatch between what is exiting the market and what is entering the market in terms of dispatchable verus variable resources presents serious questions about the economic value of variable resources on the bulk power system, particularly at higher penetration levels.

Consider the following. A recent University of Chicago study concluded that customers in 29 states with an RES paid 11 percent more for electricity in the first seven years of that RES, and 17 percent after 12 years. And much of the increase of this cost can be attributed to the integrated costs variable resources impose on the whole generation system.

Now, even the International Energy Agency found that accounting for the values of dispatchability, frequency response, and grid stabilization, coal electricity was cheaper than renewables, with the gap widening with increasing penetration of wind and solar.

But I suggest then that all this strongly suggests reweighing public policy support development and commercialization technologies for dispatchable resources. But I think these considerations also merit some attention in the state public utility commissions and bilateral markets, as they evaluate requests for plant closures and additions.

Plant owners in traditional regulated markets appear to have an incentive for retiring competitive plants prematurely, simply because they don't provide the levels of return that their shareholders now desire.

During an era of constant low growth, new capacity could be added without retiring prematurely existing assets. With little or no low growth, these utilities are now retiring prematurely existing capacity, just to make room for building something new in order to replenish their rate bases.

In short, the status quo forces some utilities to turn hostile toward very productive but highly depreciated plants. So for PUCs, as I see it, with the responsibility of ensuring reliability and affordability, it would seem prudent for them to evaluate the all-in costs of these decisions, and these include particularly the integration costs for new variable resources, such as transmission, backup resources, increased balancing and ramping pressures on other resources, and of course, the stranded asset costs that will be incurred by their customers as well.

So we look at an increasingly important market outlet and replacement of revenue stream for coal in the seaborne market on exports. On one hand, our historically go-to market, Europe, is shrinking. However, there is a raging bull story going on in emerging markets, and particularly Asia.

Think about this. While the coal fleet in most of the developed world is approaching middle age, the emerging world fleet, especially in Asia, is barely a teenager. In six countries alone, more than 1,300 gigawatts of coal capacity has an average age of only between 9 and 16 years. And these same countries have another 186 gigawatts under construction now, and another 200 gigawatts in earlier development.

So there is a great opportunity out there. But we also have to understand that seaborne markets are pretty fickle, and a lot of other factors not under our control, such as currency rates, freight costs, and trade policies can contribute to the year over year volatility in that area.

Nevertheless, we as a country, the United States, has several advantages that can be leveraged to improve our competitive position. First off, we are blessed with three coasts. Unfortunately, we are only using two of them more fully -- or being fully utilized is only on two coasts.

Political opposition to building more West Coast terminal capacity prevents western U.S. coal from performing to its full potential in the growing Asia markets. But beyond just supporting the coal industry, increasing exports of responsibly-sourced coal from the U.S. also serves compelling geopolitical objectives as well.

Many of the destinations for western U.S. coal are allies with severe energy vulnerability, energy security vulnerabilities. If we cannot deliver what they want and what they need from us, surely our competitors, whose interests are not aligned with ours or the United States will surely fill that void.

There is another development happening because of this situation on the West Coast, and it reaches beyond coal. This type of West Coast resistance is also getting attention of other industries and states, who fear that their products too will be politically targeted. And this is something our founding fathers found unacceptable when they placed the power over interstate and foreign commerce in the hands of the national government.

So the sooner -- in my view, the sooner that our federal government starts to weigh in on these state efforts to weaponize the geography for political purposes, the better off we all will be.

Now, our infrastructure is another area that needs some attention. It's sound, but it always requires continued maintenance to ensure a globally-competitive mine-to-market supply chain. This includes our inland waterways, our ports, so dredging ports that accommodate capesize vessels is important. Walking dam maintenance to minimize congestion and reduce the number of restrictive movements will also improve our competitive position.

Clearly this will take money, and that's something we need to put our shoulders behind. But also I think there is opportunities here by fully leveraging the administration's one federal decision framework for major infrastructure projects, which will expedite the review and approval of these types of activities.

Now, recall at the beginning I mentioned that prior to the era of energy scarcity in the early '70s, a large segment of our coal market was really an industrial sector. So perhaps this era of energy abundance presents a kind of back-to-the-future moment to develop a new industrial market. And this would be the advance carbon materials and products, including carbon fibers, graphite, graphene, and other precursor compounds, much of what Brian talked about. Randy is certainly very familiar in this area and breaking new ground with those opportunities.

You know, coal has long been recognized as a versatile feedstock, carbon feedstock. And it would appear that it would also possess a material price advantage at this time. With various coal costing $15 and $55 a ton, this would provide a substantially lower cost feedstock as compared to petroleum at roughly $400 a ton. And that's even before or even after adjusting for differences in carbon content.

And it may be as well that certain coals have superior qualities in the petroleum-based counterparts for these particular products, high-end products, that will be produced.

Now, I realize this potential market may not excite those who grew up in coal as a bulk and intermediate product for energy. But admittedly, the amount of coal required in this segment may not approach the volumes lost serving our electricity sector.

However, think about this. Coal prices today, on a constant inflation-adjusted basis, remain below where they were 70 years ago. And with the exception of a decade following the energy crisis in the '70s, prices have generally left producers with thin margins and chasing volumes. So participation in a value-added supply chain may provide a welcome price and margin breakout for those coal producers who are participating.

And perhaps this is an opportunity as well for coal to expand -- extend its legacy from powering their role to building it as well.

So I'll just close up by noting that I suspect some of my observations don't strike some of the answers that are particularly unique or new, and especially those of you have been engaged with the National Coal Council. The council has done some excellent work exploring the future opportunities for coal.

Janet, you and the members of the National Coal Council are to be commended for looking beyond the present and outlining the next chapter, potential chapter, for our industry.

And I also would note that the opportunities we discussed this morning to me also affirm the real value of the Department of Energy in driving innovation. It's so important to ensure that American deliver on its full energy potential. DOE and its labs, and the institutions it has partnered with over the years, have probably been involved in every important breakthrough technology-wise for energy resources, especially coal.

So that's another reason, as I said at the beginning, I continue to be very optimistic about coal's future. We have partners with a proven track record for delivering and game-changing results.

So with that, my thanks to all of you for your efforts to shape coal's next chapter, a mission I think continues to be vital for our nation's continued success, and I wish you my best wishes to you for all your future endeavors in that area. So thank you very much.

(Applause.)

MS. GELLICI: Thank you, Hal. I appreciate that.

Are there any questions for Hal at this time?

Hal, thank you so much for the overview and for your thoughts about the future. One of the things that we hear a lot about is the demonization of coal and the public image. And I'm wondering if you see anything going forward that the industry might do to kind of change that perception of the industry. Are there things in your toolbox that you think we could make use of that would be helpful there?

Can we turn mic on, on that table, please? Thank you. There we go.

MR. QUINN: Well, thanks, Janet. I think you have to understand what we're up against in terms of the financial resources when it comes to public image. So you're looking at more than dozens and dozens of groups who are truly focused on one thing, which is demonizing fossil fuels, starting with coal, as you know. And so the approach is really -- you know, I see two approaches to how we -- not how we deal with coal, but how the people approach coal.

And as I testified recently at a hearing about that, when some of the Democratic members were expecting, you know, some kind of climate denial witness from the mining industry, you know, my view is this. We can either -- we have two routes to go if you're really concerned about climate. And this has to do with also public image as well. You can either do the Michael Bloomberg approach, which is you put a lot of money to get symbolic victories by putting one particular industry out of business.

But you won't change anything in terms of the end result. Or you can do the Bill Gates' approach, which is all built on technology, being patient, and figuring out how you build that into the economic systems in a competitive manner.

Our public image, it's not all as bad as one might think. We did some recent polling and still shows still an amount of support for all of the above, also investing in existing coal plants. But there is a little bit of erosion there in terms of a number of people who think it's awfully important to preserve coal as an energy option.

MS. GELLICI: Any questions for Hal?

Let me acknowledge that Hal will be retiring as of the end of this year, and I wanted to take a moment to thank you for your tremendous service to this industry for many, many years. You will be greatly missed, and we greatly appreciate your support and all of your leadership over the last years, Hal.

Please join me in thanking Hal for his service.

(Applause.)

MR. SARKUS: At this time, we're going to take a little break. Everyone can stretch their legs, get a drink, or use the restroom. Let's plan on meeting back here in 30 minutes so we can start back up again at 10:15.

(Whereupon, a brief recess was taken.)

MR. SARKUS: I hear the toll of the bell.

(Pause.)

MR. SARKUS: So, ladies and gentlemen, if you could please be settled, we'd like to get started. Thank you.

(Pause.)

MR. SARKUS: Now I ask that Ms. Janet Gellici please come up to announce the rest of the speakers. And thank you, Janet.

MS. GELLICI: Thank you, all. I appreciate your reconvening here. I wanted to thank Peabody for hosting our keynote session this morning, and I would like to thank Ramaco for hosting our industry presentation session.

Before we get started with the rest of our program this morning, I'd like us to take a moment of remembrance for a couple of our friends who have recently passed. Those of you remember -- who have been long-terms members of the Council and remember Janos Beer, who was a member of the Council, a very longstanding member of the Council. Janos passed away in December of last year, and we haven't had a chance to honor and remember him.

Janos was a tremendous Renaissance man. He was a violinist, a humanitarian. He helped rescue many of the Jews in World War II out of Hungary. He was world-class rower and engineer, a fuel scientist. And he ended his career at MIT.

Last week we lost Doug Carter. Many of you know that Doug was one of our lead authors on a report that we did in May of 2014. It was actually the first report that I had a chance to work on when I took over as CEO of the organization. Many of you know Doug from his time at the Department of Energy, EPA, and OMB. He was a tremendous technical person, consultant. He had the wonderful ability to take things that were very technical in nature and make them understandable. He was an extremely wonderful communicator, very witty, knowledgeable, a great writer, and a kind person.

So if you'll join me in just observing a moment of remembrance for these two friends.

(Pause.)

MS. GELLICI: Thank you. It's my honor to introduce Hilary Moffett, who is our senior director of government affairs in Washington, D.C. for Occidental Petroleum. Hillary's responsibilities include advancing the interests of Oxy and Oxy Chemical, which is a wholly-owned subsidiary of the company, working with policy and advocacy strategies here in Washington, D.C.

Prior to joining Occidental, she led the environmental strategies committee for the American Petroleum Institute, so she has a great basis in a lot of the energy industry. She has also served as majority counsel on the Senate Committee on Environment and Public Works. She is a native of Tulsa, Oklahoma and graduated from Washington University in St. Louis with a BA in international relations. She received her JD from the University of Oklahoma College of Law.

Would you please join me in welcoming Hilary Moffett. Hilary.

(Applause.)

MS. MOFFETT: Thanks, Janet.

Thanks, everyone, for the opportunity to speak here today about a company that's doing some really incredible work, and where we see opportunities for continued growth. As Janet said, I'm Hilary Moffett. I'm based here in the D.C. office, so I spend a lot of time talking to legislators and regulators about our industry and the kind of work that we're doing.

So I want to start the conversation today with a little bit about Occidental, and then I will move into more detail on the newly-formed Oxy low-carbon ventures, and some of the work that we're doing there with carbon capture technology.

So this is just a little bit about who we are now. Most people have never heard of Occidental because we're not consumer-facing. So we don't have gas stations. We don't have products on the shelf. Just recently, though, we acquired Anadarko Petroleum, and that makes us about the third largest oil and gas producer in the country. We're right around 1.3 million barrel-of-oil equivalent per day.

The majority of our operations are and have always been in the Permian Basin. But this acquisition brought on assets in the Gulf of Mexico, Utah, Wyoming, and Colorado.

Internationally, we focus in the UAE, Oman, and Colombia in South America, with a global headquarters in Houston, Texas. As Janet mentioned, we also have a chemical subsidiary, OxyChem, where we're the leading manufacturer of chemicals that go in to make plastics, pharmaceuticals, and water treatment.

Our CEO, Vicki Hollub, believes that we need to address the issue of global climate change. We're proud at Occidental to be part of the Oil and Gas Climate Initiative, API's environmental partnership, and a number of other organizations aimed at reducing greenhouse gas emissions and utilizing best practices to decrease our footprint.

We believe that we have to take action today to reduce emissions on a global scale. And as part of that, just this year we announced our aspiration of becoming carbon neutral. Oxy is a unique company because we are actually the world's largest consumer of CO_2. We have over 40 years' experience in separating, compressing, transporting, and injection CO_2 for enhanced oil recovery.

Right now, we inject about 2.6 billion cubic feet of CO_2 each day from naturally-occurring anthropogenic and recycled sources of CO_2. That's about 50 million metric tons per year. And of that 50 million metric tons, about 18 million metric tons is permanently sequestered in the geology of the reservoir. So for context, 18 million metric tons is the emissions equivalent of about 4 million cars. So every year, we're putting the emissions from 4 million cars and permanently sequestering that underground.

So we know that that CO_2 stays underground because we have two MRV plans approved through U.S. Environmental Protection Agency. So MRV is for monitor, reporting, and verifying. Those plans are actually made publically available, so if you ever need some light reading material, it's actually only 45 to 50 pages, and it goes in-depth about all of our knowledge of the geology of the reservoir, why the CO_2 stays underground, how things move underground. And so that's how we can be sure that we're putting there stays there.

We spent many years developing and perfecting this technology, and we continue to invest and grow and innovate in this space in our understand of all the rock.

So like I said, we have been sequestering CO_2 safely and reliably in the Permian Basin for over 40 years. We've conducted hundreds of reservoir studies, and we have massive amounts of data supporting the viability and safety of CO_2 in oil and gas reservoirs. To date, we've sequestered more than 400 million tons through 36 CO_2 floods that we currently operate.

Our net production related to CO_2 EOR is an additional 155,000 BOE per day. So ever day, we get an additional 155,000 barrels of oil equivalent, just through using CO_2 for enhanced oil recovery.

So as part of our carbon neutral aspiration, we spend a lot of time working toward the carbon neutral barrel of oil. For every barrel of oil, about .8 million cubic feet of CO_2 is emitted. If we can sequester .8 million cubic feet of anthropogenic CO_2 per barrel of oil, we're approaching the carbon-neutral barrel with the potential of creating a carbon-negative barrel of oil.

So in order to get to carbon neutral, we need to access more anthropogenic CO_2. 45Q was the tax credit that was expanded and extended in 2018, and that really helped to incentivize the capture of CO_2 from facilities across the country. The tax credit acted to help cover the costs of capture equipment so more folks were incentivized to build the equipment on.

This legislation enjoyed bipartisan support in both the House and Senate, and has enabled us to embark on exciting new partnerships. And I'll discuss a little bit of those just in a minute.

So with 45Q, we have the incentive to capture CO_2. With Oxy's enhanced oil recovery, we have the demand for CO_2. We just need a way to get the CO_2 from source to sink. Currently, we operate about 5,000 miles of CO_2 pipeline in this country, and Oxy owns about 2,500 of those. But in a hearing last May in front of the Senate Energy and Natural Resources Committee, Steve Winberg said that we would need at least 10,000 to 30,000 miles of CO_2 pipelines in this country.

So we're considering this need, and have developed the idea of a Midwest superhighway. This CO_2 trunk line would transport CO_2 from up to 57 industrial sources, including coal, ethanol, cement, and ammonia facilities in the Midwest. So you would capture all of those through different feeder lines into the Midwest trunk line, and that would bring it down into the Permian Basin for enhanced oil recovery.

Eventually, we see those pipelines as bringing the CO_2 down, like I said, to the Permian Basin, but then elsewhere as we start to embark on CO_2 as feed stocks and in use in other types of materials.

Now, one thing I will mention about this, the CO_2 pipeline permitting process right now is very difficult, and it's housed in lots of different places. So something else that we're spending time thinking about and working on actually from a legislative perspective is the Use It Act, which is legislation that will help streamline the CO_2 pipeline process for permitting. Well, there we go.

So the question then is if we're able to get all the CO_2 down to the Permian Basin, what is the storage potential? So we've been looking at Permian Basin in particular, and we believe these reservoirs are capable of storing total U.S. emissions for the next 200 years in the Permian Basin alone.

We already have the infrastructure, expertise, and experience in place, and we're taking action to start sequestering this anthropogenic carbon at a massive scale. And like I said, all of these efforts are supported, monitored, and verified by U.S. EPA and a number of independent experts in academia.

So that's a little bit of Occidental and our enhanced oil recovery. But I want to do now is shift to Oxy Low-Carbon Ventures. So Low-Carbon Ventures was formalized in the summer of 2018 to serve a dual purpose, to enhance Oxy's profitability and shareholder value in the transition to a low-carbon economy and to reduce our greenhouse gas footprint. And we want to help others do the same.

So low-carbon ventures is a wholly-owned subsidiary of Occidental Petroleum, and their focus is to decrease our carbon footprint through low-carbon energy solutions. Our goal is to lower the cost of capture so that we can make more widespread the capture and use of CO_2.

Low-Carbon Ventures is looking at opportunities that utilize CO_2 to create products, such as plastics or CO_2 as feedstocks for fuels to help decarbonize the historically difficult transportation sector. We've already embarked on a number of projects, and I'll share just a few of those this morning.

So last year, Oxy announced a feasibility study with White energy, a biofuels producer in Texas and Kansas. This study would outline options for capturing CO_2 from two of White Energy's ethanol facilities in West Texas and bringing that -- and transporting that anthropogenic CO_2 to the Permian Basin for injection.

The project could potentially sequester approximately 1 million tons of CO_2 per year. So a typical passenger vehicle emits about 4.5 million metric tons of carbon dioxide -- I'm 4.6 metric tons of carbon dioxide a year.

So this project has the potential to remove the carbon dioxide equivalent of about 200,000 cars per year. It's an important first step in cross-industry collaboration to make carbon capture economic, practicable, and scalable. And when I go in and I talk to regulators and legislators, and I can say that I'm probably one of the only oil and gas companies that actually really likes to work with ethanol. You don't see a lot of those.

So in November, Oxy joined Exelon, McDermott, and Eight Rivers to partner with Net Power, which is a zero-atomospheric emissions natural gas power generation facility. Net Power is really incredible technology, and I am not a scientist, so I'm going to go too much into detail. But I'll give you a little bit of the high level.

So it uses supercritical CO_2 instead of steam as a working fluid. It combines oxygen and methane combustion technology with CO_2 as a high-temperature working fluid, and it inherently captures all the CO_2. So this oxy combustion technology historically has not been economic. But by capturing and reusing the produced CO_2 into the combuster, Net Power has created a cheaper, cleaner alternative to traditional natural gas power plants.

This technology is known as the Allam Cycle and generates zero atmospheric emissions. Byproducts are water, nitrogen, argon, and pipeline-ready CO_2. So we see the potential for this pure stream of CO_2 to be utilized in our enhanced oil recovery operations. Net Power's power generation technology with inherent carbon capture compliments Occidental's leadership in CO_2 utilization and sequestration, making us ideal partners to tackle carbon emissions worldwide.

Last year, Oxy announced a partnership with Carbon Engineering, a British Columbia-based company that has been developing direct air capture technology since 2009. In 2015, they opened the first pilot plant for direct air capture. In May, Oxy announced a joint venture with carbon engineering to bring the world's first commercial scale direct-air capture facility to Texas. So it will be removing carbon dioxide directly from the atmosphere.

The facility will remove CO_2 at about 1 million tons per year. The direct air-capture plants are location-independent. So you can colocate them with an oil field for enhanced oil recovery. And using atmospheric CO_2 for oil recovery greatly reduces the carbon footprint of a traditional barrel of oil and opens our pathway to the carbon-neutral barrel.

We plan to begin construction on this commercial-scale facility in 2021, and hope that it will be operational by 2023.

So I always like to point this out because Oxy really is an all-of-the-above energy company. We use natural gas and coal for electricity. We partner with ethanol. Some of our OxyChem facilities have cogeneration technology that allows us to use the hydrogen byproduct to power the chemical operations. And we're now expanding into solar.

So about a third of our costs in the EOR field is electrical generation. We're currently installing a 16-megawatt solar facility at our Goldsmith unit, which will reduce our scope on emissions and help us with energy efficiency costs.

So we see CO_2-enhanced oil recovery as a first step of many in creating ways to decarbonize. Transforming carbon emissions into feedstocks for plastics, building materials, and other products is an exciting way to reduce atmospheric CO_2 while continuing to add value to the economy.

But it's of the utmost importance that we continue to develop and perfect ways to capture and transport CO_2. This includes efforts to improve upon and expand the 45Q tax credit, and pass the Use It Act for CO_2 pipeline permitting.

So we must work with parties across all sectors to create a pathway for the low-carbon future. By partnering with ethanol, coal, steel, cement, and others, we can ensure a win for emitters, producers, and the environment. So we see four main steps to building and deploying this technology.

I talked a little bit about the capture technology. For now, that includes the capture facilities both from point sources and direct-air capture.

Transport. Building upon the 5,000 miles of pipeline will be important to ensure that captured emissions can be utilized efficiently and effectively. But it requires many more pipelines and a better process for permitting.

Number three, storage and use. As I mentioned, we have stored over 400 million tons of carbon dioxide to date, and we've done so safely and reliably.

And finally, public trust and acceptance. I mentioned the MRV programs, the reporting, monitoring, and verifying programs. And we need to continue to utilize the expertise both at DOE and the EPA. These MRV plans create a transparent process with public input and the opportunity to engage, and maintaining that is really important to the future success of these programs. We need to continue to work with regulators and legislators to ensure strength and transparency in the oversight.

So I'm thrilled to be working with a company that's doing lots of incredible work to decrease emissions and increase production of domestic energy sources. At Oxy, we want to enhance profitability and shareholder value in the transition to a low-carbon economy. It's the right thing to do, and we're proud to work with other stakeholders in this vision.

So I can take questions now, if anyone has any -- oh, there is all of the legal stuff, which I know is very important. But, yeah, happy to take any questions.

MS. GELLICI: Would you please join me in thanking Hilary Moffett.

(Applause.)

MS. GELLICI: Do we have any questions for Hilary that we can take from the audience?

Casey, would you grab that mic? I'm sorry.

I don't know where Hiranthie is. She's probably busy. But if you'll state your name and affiliation. Thank you. It's on.

MR. KAPTUR: Is it on?

MS. GELLICI: Yes.

MR. KAPTUR: Thank you for your comments. My name is Casey Kaptur. I'm with RPM Global. CO_2 floods for enhanced oil recovery, that's a pretty mature technology. But when I think of that, I usually think of it in regard to traditional vertical wells. Is it also applicable to what we broadly call fracking?

MS. MOFFETT: So we have been exploring using CO_2 in the unconventionals. We have done a couple of pilot programs, and so far things are successful. But you're right to say that right now everything is just conventional.

MS. GELLICI: Hilary, when you work on the Hill with the regulators, are you finding more folks receptive to the idea of CO_2 capture, and maybe what are some of the concerns or questions that seem to come up from them?

MS. MOFFETT: Yeah. So -- and I'll start this with my own admission. When I started with Occidental, I didn't know a lot about enhanced oil recovery and carbon capture. And so when you're talking about some of these things that I mentioned today, like direct-air capture, like the ability to pull carbon dioxide out of the atmosphere and use it in enhanced oil recover, it seems a little like science fiction.

So a lot of what I've had to do is the very low level education efforts to start. But increasingly, what I hear is people are really excited to hear about it, and they want to know more. And that's in part because right now the politics are very difficult, especially as it relates to climate change.

So giving folks something that they can support as it relates to climate solutions, is something that is widely accepted and appreciated. For so long -- and it doesn't have to be a Republican/Democrat issue, but for so long Republicans especially haven't had a strong argument when it comes to climate solutions. And I know that because I worked on the Environment Committee under Senator Inhofe.

So increasingly, what I'm finding is you have people, Republicans especially, that say help us find a solution here because we recognize that there is a problem, but the Green New Deal isn't the solution. So what can we be for? We don't want to be against everything, but we have to be for something. But we want it to make sense.

So when we come in, and we talk about pro-business, pro-domestic energy, and decreasing greenhouse gas emissions, people are really excited to hear about it. And even further, I'll say they're excited to see that we're actually putting money in these investments. We don't just talk about it. We've been doing it for a long time. But how are we expanding into new areas that we think can keep up with the times, I think is something that people are really excited to hear about.

MS. GELLICI: And can you share with us maybe a few high-level points on the Use It Act? I think the transport option is so critical to getting these technologies advanced. So I think that's important, if you could just share a few points on that.

MS. MOFFETT: Sure. Yeah, you know, one of the things that we spend some time thinking about is -- the word pipeline, people don't love it. I mean, you think about Keystone. You think about oil and gas pipelines, and you think about all kinds of issues with that.

And so I'll start with something that we're trying to do is educate members of Congress and regulators and the general public, on the differences between an oil and gas or -- yeah, an oil and gas pipeline and carbon pipeline because they're very different. And that actually is reflected in the way that they're regulated.

Right now CO_2 pipelines spans lots of different agencies, and it's a very difficult process to try and expand. The other thing we're trying to be cognizant of is the future demand that we foresee. So I don't know if I can get back to this Midwest pipeline. But what we really want to make sure and do is build a pipeline for future demand, not demand today because we really see so many opportunities with these 57 capture facilities to bring on lots of supercritical CO_2, but in order to do that, we need a pipeline that fits it all.

So one of the things that we're spending time working with internally and with other shareholders -- I mean, sorry, other stakeholders --is how can we build a pipeline that would fit the demand for 57 facilities. So the Use It Act is legislation that helps -- among other things, there is some money in there for direct air-capture technology. There is some different programs at Department of Energy and Environmental Protection Agency, but it also helps streamline that process for the permitting that looks a little bit more like it would for an oil or a natural gas pipeline.

So that will make it easier when we get to the stage that we can start to really look at something like this, and what the process would be for all of your permitting, your environmental impact statements, and working with state and local governments. We'll have a more clear understanding of how we can do that properly.

So the Use It Act is interesting because has bipartisan support on both the House and the Senate. 45Q, bipartisan support on both the House and Senate. So that just goes back to my point that we really see a little of people on both sides of the aisle that are really interested by this idea, and want to know more and want to be engaged.

MS. GELLICI: We'll end on that note with the good news on that. Oh, there might be one more question from Mike. I'll make you walk. Thank you.

MR. MOORE: Hi, Hilary. My name is Michael Moore, TWSA. And great stuff. And I know Oxy has been a leader in a lot of these things, and it's always great to see even more of this. Quick question. To do this kind of a pipeline system, CO_2 pipelines do not have eminent domain or coverages in their state system. How do you get through that mess of state-by-state land acquisition and right-of-way perfection?

MS. MOFFETT: Yeah. So we're certainly not getting involved in the eminent domain conversation on this one. But one thing --

MR. MOORE: Of course.

MS. MOFFETT: -- that we are working, there are different legislative proposals, and some of them actually would encourage the use of existing rights of way and existing -- you know, in the pipeline corridors. So that's an option. But, I mean, the other option it was just going to take a lot of work, and especially something like this where you're going through five states.

So, you know, we don't want to get involved in eminent domain, but we are looking at different ways that perhaps already exist. Now, this pipeline was mainly drawn out based on where the capture facilities would be located. So how can we get the most bang for our buck? And actually, there have been other states that were originally put into this and were cut out later.

But, I mean, it certainly would be a challenge.

MR. MOORE: Right. I had at one time worked with a group with a proposal of adding three words to the Natural Gas Act were "and carbon dioxide," to give them the same coverage under FERC and that whole eminent domain issue. And, of course, any time that was brought up, it was rejected very quickly. But at that time the idea of superhighway for CO_2 pipelines was literally a pipe dream back then.

MS. MOFFETT: Yeah.

MR. MOORE: Now it's different. And I'm wondering if somebody with enough pull will show up with that again.

MS. MOFFETT: Yeah. You know, actually, I had a conversation with Chairman Chatterjee about this months ago, just about sort of where there are holes and why it was created like this. And I think you're right. This was just not something that people really foresaw.

And so we're having to do a little bit of back work to try and figure out where this could fall, what would make it most effective, both for our purposes, but for the greater good, too. I mean, we want to be very cognizant that we're doing a lot in this space. But in order for these programs to be successful, we need lots of other people to jump into this space as well.

And we've said that with 45Q. You know, in order to have the continued success, people need to utilize it. And we need to be able to go back to Congress and say this is a program that people are really taking advantage of. You know, help DOE do more.

So it has taken a lot of education and a lot of imagination on our part, too.

MR. MOORE: Thank you.

MS. MOFFETT: Thank you.

MS. GELLICI: Hilary, thank you very much.

MS. MOFFETT: Thanks.

(Applause.)

MS. GELLICI: So we'll not use the word pipeline, we'll talk about CO_2 highways from now on. So thank you very much for your presentation, Hilary.

It's my pleasure to introduce Jason Selch, who is CEO of Enchant Energy Corporation. Enchant Energy is acquiring the San Juan Generating Station near Farmington, New Mexico. They have plans underway to retrofit the San Juan Generating Station with state-of-the-art carbon capture equipment that will transform that facility into the lowest emission fossil fuel plant in the western U.S.

Jason is a professional investor in the energy industry, with over 25 years of experience, and is a partner in Acme Equities, which is an energy investment firm. He received his BA in economics and his MBA in finance and accounting both from the University of Chicago. I recently saw Jason present at a USEA event and was very impressed with the plans he has underway, so I invited him to join us.

I think he brings a tremendously unique perspective with his finance and investment background, and so in particular I'm glad he's here to share with us his plans for the future for the San Juan generation station. Would you please join me in welcoming Jason. Jason?

(Applause.)

MR. SELCH: Well, first of all, Janet, thank you very much for inviting me. So this is a conference where last night's keynote speaker was the chair -- is the chairman of the Federal Energy Regulatory Commission. Dr. Anderson is running NETL. Hilary is from one of the leading companies in the United States.

Enchant Energy is a company I founded this year. We have four employees. It's an independent power development company. We are acquiring the San Juan Generating Station. We've created a public/private partnership with the city of Farmington. We are not a gigantic organization, but we have a very important project, and it's a very important project to everybody here.

So let's see. Here it is. Excuse me.

MS. GELLICI: I'm sorry, Jason. It's the one that's the down arrow, believe it or not.

MR. SELCH: Okay. Sorry about that. So the first statement is that San Juan Generating Station is perhaps the best site in the U.S. for next large-scale installation of carbon capture utilization storage technology. There are a number of factors that we're going to go into about why that is the case.

It is very important for this industry to move forward with a large-scale project and one that can be financed in the private market. And so when you have the best site, it's the project that could be most easily financed. And we actually think that if everything goes correctly, that it could be online sometime in 2023.

The coal industry and the coal-fired

generation industry is facing huge challenges. They need to come up with a way to be able to continue to supply low-cost energy while at the same time doing their part to reduce CO_2 emissions and have environmental stewardship.

This project is also -- so this project is very important for the industry because the industry needs to demonstrate that there is a way that they can coexist in the environment that we have today that's very climate-conscious. It is also very important for our planet. So not being a professional scientist or environmental researcher, I have just reviewed a lot of research in the public domain. And there is pretty much general consensus that in order to achieve the 1.5 percent -- 1.5 degree ramp for temperature, that carbon capture is necessary.

Carbon capture, it is not going to happen on its own. It has to happen the same way that other technologies have been developed, which is that you start with some projects that are very high cost, and then the next one is a lower cost, and the next one and the next one.

In this technology, the carbon capture technology using post-combustion aiming-based technology. So that's the technology we're going to use. That is the off-the-shelf technology. There have only been two commercial-scale projects attached to coal-fired power plants, one which is the Boundary Dam in Canada, and the other one, which is the Petra Nova project in Texas.

Boundary Dam came online in 2015, and the Petra Nova in 2017. If we fit our schedule, we will come online in 2023. Six years is too long a period of time between one iteration and the next one. We need the projects to go one after another so we can really improve this technology, and we really need this technology in order to address climate change for the planet.

And, you know, the United States, I think is doing a very good job of its part of reducing its emissions by basically moving from coal-fired generation to gas-fired generation. But that's not -- the United States can't do it on its own. We need to develop this technology and we need to export this technology.

So the project that I'm involved in, although it's being sponsored by a small company and in conjunction with city of Farmington, it's very important for the coal industry, and it's very important for our global climate agenda.

When we started looking at this, we found that in the literature again that carbon capture technology had decreased in cost, that the previous view had been that it might cost about $65 a ton of carbon to take out the carbon dioxide. But then there was recent studies actually last year, and it said maybe the cost had come down by 30 to 35 percent.

So the first thing that we did was we hired the engineering firm Sargent and Lundy to look at how much would it cost to do carbon capture at this particular site, and they came up with the price of $39 to $43 per metric ton. And that is a price range which would make this project financeable in the private market, and also would make it so that the carbon capture process could be self-financing, and therefore would not increase the cost of generation of the power plant.

So much of the criticism of this technology is that it is too expensive, and that it will increase the cost of generation, and with coal-fired power competing, the competition is very difficult with natural gas-fired power. Adding carbon capture is not something that hurts. In fact, the way we're structuring the deal, it basically provides an inhouse customer for about 29 percent of the electricity generation and the steam.

Using carbon capture is also something that works very well at the local level. So I'm going to talk in a little bit about the public/private partnership. But the result is that by adding carbon capture to an existing coal-fired power plant, it is excellent for the environment. So carbon capture with the currently-available technology reduces the output -- the intensity of the carbon dioxide from 2,200 pounds per megawatt hour down to 250. It's a 90 percent reduction.

Two fifty is less than a third of what -- in the intensity of a combined cycle power plant and less than a quarter of peaking unit. So it's very good for the environment. It's very good for the ratepayers. It is very good for the ratepayers because with the availability of a market for the CO_2 -- and I tell how this project is close to the Permian Basin so it works for having a market.

With 45Q tax credit, those two things make this self-financing and therefore does not increase the cost of power. And the power plant can continue to run as it has been, as a low-cost generator in the market. Then the third thing is, is that it's a way to address the climate while at the same time maintaining the continuity of the community. So where this plant is located in New Mexico, this is a very significant employer because the mine and the power plant are colocated to the same area. And if the plant were to shut down, it would be devastating to the community. So we're really achieving all three of those of win-win-win goals.

What is the San Juan generation station? So currently configured, it's a 847-megawatt power plant that runs on a very efficient low-cost coal supply from a mine that's located basically underneath the power plant, located in Northwest New Mexico. Very fortunately, it has very good access to transmission to take electric power to Colorado, Utah, Nevada, Arizona, New Mexico, and California.

And since the plan is to take it out of rate-based and turn it into a merchant plan, having access to a lot of markets is the key thing. It is currently owned by a number of utilities. And the utilities have all elected to abandon the power plant for their regulatory processes, and we've acquired the right to take over the power plant in 2022, when the current owners are going to abandon the power plant.

The power plant -- some of the advantages of the power plant from the point of view of why it is that its cost of capture is $39 to $43, which I think is a low price compared with other different opportunities to do this, is because in the past five or six years, they went through a process to upgrade the environmental controls in the power plant.

They invested hundreds of millions of dollars to comply with regional haze. And they put on state-of-the-art emission control to control various different emissions, NOx, SOx, mercury particulate. They have balanced draft. They have a whole bunch of stuff. So it benefits from having, with the exception of carbon dioxide, a very clean stream of emissions.

So when you put carbon capture onto a power plant, it's best to start with the stream of emissions that doesn't have a lot of other substances in it. The other thing is that in conjunction with the settlement with the EPA regarding the regional haze, they decreased the size in the power plant by about a half.

What that meant was -- what that means is that there is plenty room in the footprint of the power plant to put on the carbon capture. We're going to do it with different units, so there were originally four turbines. Two have been shut down. We're going to attach carbon capture to two of those.

We think that that's also very good from the point of view of reliability of electrical generation and actually reliability in terms of the carbon capture. It's just very good to have a power plant that isn't dependent on just one, you know, one system.

So we have two in there. And when it was downsized, in addition to that, it has the water handling equipment and most of the cooling towers for a four-unit power plant and piping and auxiliary power and many things. So those are some of the advantages of the plant.

This is a picture of it. And I just -- we had this taken this year because all the other PR things in the public domain show four stacks going with black smoke. And this shows two stacks with, you know, very clean emissions, and that's because this is done after the downsizing.

But this project is being vigorously attacked because there is a strong interest amongst groups that carbon capture should not be successful, and this is a very good place to do it. So it's being attacked. And so I want our own picture out there that shows there are only two stacks, and the stacks are very clean in emissions, with the exception of CO_2. It pumps out a lot of CO_2.

Enchant Energy, we just formed it this year. And my partner and I, we are entrepreneurs and have been investors in this industry for a long, long time, the energy industry broadly speaking, and we're working with a number of different consulting firms and law firms, and we applied for a grant in May from the DOE for the feed study, and we're waiting to hear what the decision is going to be on that sometime soon.

This is where the San Juan Generating Station lies on the supply curve. So it is lower-cost than practically any gas-fired power plant out there. And it's a low-cost power plant.

This is kind of a schematic. Well, let me get to the next page. So, when we were approached by the City of Farmington to take over this power plant and do something with it, my initial thought was that I hadn't practically ever heard of such a stupid idea, to try and turn a coal-fired power plant into a merchant plant.

But we had actually been doing some work for one of the major CO_2 companies. Actually, we had been doing some -- had a lot of interaction with Kinder Morgan in 2018, and they had actually told us that there's a very strong interest in the oil and gas industry, which kind of has been repeated here, to shift from using CO_2 that comes from underground to CO_2 that is captured, captured CO_2.

So, after I thought that this was a stupid idea, my colleague said, well, let's see where the Kinder Morgan pipeline goes. So we pulled up this. This is from their website. And just there where the pointed arrow says Cortez Pipeline, that's basically Farmington. So that's where the power plant is. So we're like, okay, well, let's see if there's something we can do with the power plant because it's right next door to a CO_2 pipeline, and we know that the oil and gas industry really wants to switch over to this kind of captured CO_2.

And so, you know, we were developing this project. This is a schematic that I put together, and I think that there's a lot of misunderstanding about carbon capture. So carbon capture is that you have a coal mine and it produces carbon in the form of coal. I understand that they're very complicated molecules, and we should use their molecular structure. But we do combust them. And when we combust them in a normal power plant, they produce 2200 pounds per megawatt hour of emissions, and they are the principal source of carbon dioxide in the atmosphere. And that's a big, huge problem.

When, on the other hand, you take the coal, you combust it, about 10 percent goes into the atmosphere, and that's the 250 pounds per megawatt hour. The balance, the 1950, is shipped by pipeline and, because of the proximity of the Cortez Pipeline to this location, there isn't a very big pipelining issue. And then it goes to an oil field and it can be pumped underground.

So it starts as coal underground, the carbon. A little bit of it leaks off into the atmosphere while you're using it, while you're creating energy. And then it goes back into the ground. So it just comes from where it went, except maybe -- well, we're hoping that it's going to be pumped into an oil field in New Mexico because, in the State of New Mexico, the severance taxes go to pay for the Department of Education, and we want to say that, by capturing the CO_2, we're helping the Education Department too.

We need a lot of political support on this project. So wherever we can get it, we want to get it. But then it kind of goes down into the ground. I think one of the questions that a lot of people ask about carbon capture is why don't you do that and then just dump it in the ground. There are certain formations called saline formations that you could easily bump it into in the ground that don't produce oil.

So why is it that we would want to bump it into the ground to produce oil? The main reason is is because this project is going to cost $1.3 billion. We're going to have to raise financing to do that. We need counter parties who are going to be able to guarantee that the carbon dioxide that goes in the ground stays in the ground and never comes out.

And so the oil and gas industry has basically said we can be your counter party because, actually, they have a track record of -- did you say 50 years? -- 50 years of using CO_2. And I want to check that study that you were talking about. You told me that it's on the website, right? Because I've been looking for that data because other people have said to me, well, you know, you're going to pump it underground, then it's going to come out into the atmosphere eventually.

But then I've spoken to people in the industry, and they're like, no, it stays underground there. So I want to see these scientific studies. I think that's very important to be out there, and I'm really glad that you're making it available to the public.

So we need the oil and gas companies as the counter parties, but if we didn't -- if we weren't financing it in the private market, you know, if somebody came along and wanted to give us the $1.3 billion, we'd just be happy to pump it into saline solution.

This is just a chart that -- the Clean Air Task Force is one of the environmental organizations that is a very strong supporter of carbon capture. And they are using their kind of analysis to show that when you pump the carbon dioxide into an oil and gas field, it is much less carbon-intensive than if you drill a new well. And this is kind of their analysis.

But you know what? I spent my whole career working in oil and gas, and what I know is that the carbon dioxide goes down into the formation and then it's really just the energy that's used. And the rest of the oil and gas industry, you have to drill a whole bunch of wells. There's a bunch of things here. We're just really using the energy. And I think it's very environmentally benign.

Now it happens that it means that you have to have a partnership or some kind of a deal with an oil and gas company. We all know that they are like -- did somebody call them criminal? Well, anyway, but they are not. But anyway, this is the results of the Sargent and Lundy scoping study, and there you can see that they're saying $39 to $43 a ton is the cost. They basically said that, in this particular location, it's going to cost about $1.3 billion. The operating costs are going to be about $100 million a year. That $100 million a year will be covered by the sale of the CO_2. That's the other reason we need an oil and gas company, is that we need an entity that will buy the CO_2 to pay for the operating costs that we're going to have.

And that operating cost includes the cost of the electricity that's used, the 29 percent of the electricity. This is based on thinking that there's 29 percent of the electricity that would have to be used for this.

Over 12 years, at 6 million tons a year captured, that's $2.5 billion of tax credits. $2.5 billion of tax credits is enough to finance something that's going to cost $1.3 billion. And as I was saying, the sale of the CO_2 will cover the operating costs. And as a result of that, the project can be developed without burdening the power plant with an increase in power costs.

This is why this is great. This is going to take 6 million tons of CO_2 out of the amount of emissions that are being emitted today in the United States. That's a very big number. That probably is more than is being captured by all the other carbon capture projects in the world.

If they take this power plant and they were to replace it with a natural gas-fired power plant, then that power plant would generate 27 percent more CO_2 than this power plant with carbon capture. So if you took -- for example, if you took the 1100 per megawatt hour, pounds per megawatt hour, times eight hours, and then you compared that with 24 hours at 250 for a carbon capture plant running 24 hours, basically, the gas peaking plant generates 27 percent more CO_2 than running a coal-powered power plant 24 hours with the much lower emission rate.

Oh, okay. We also think that this is going to be a cheaper way for the ratepayers in New Mexico, and it's going to save 458 jobs, 1,000 nondirect jobs, 8 million of local tax revenues, and something that's undefinable that we're very excited about is that, by having kind of the third commercial-scale project, it's going to allow New Mexico to become a leader in this technology, and we don't know -- people who work at that plant will probably be deployed as this technology spreads around the world.

I'm going to forget about that. This is -- some people from -- the leaders of Farmington, New Mexico, have joined us at this conference. And it's a very poignant story that the project -- the power plant was going to be shut down or is planned to be shut down. They hired a consulting firm to figure out what the impact was on their economy. It told them that the impact on their economy would be devastating.

Instead of sitting around and saying, oh, well, you know what, things happen, and it's all being kind of driven by people outside of our community, whether it's the utility or whether it's the environmental mandate or whatever it is. They said, okay, well, we got to do something about that. So they hired a law firm in Washington who found my firm, and then we found that carbon capture technology would work here, that it would be very cost-effective.

And I think that that's really an excellent role for the local government, is to find a way to solve a problem that has been created. And I'm very honored to introduce Mayor Nate Duckett, who is here, and he's going to talk a little bit about how this came about.

Mayor Duckett, thank you.

MR. DUCKETT: Thank you.

(Applause.)

MR. DUCKETT: Well, first, I just want to say it's great to be in a room full of people who are invigorated to try and find solutions to not just the climate issue but find solutions for our workforce. And that's really why I'm here, and that's really why we have taken the steps that we've taken as a municipality, as a part owner of San Juan Generating Station to try to find solutions to keep our community whole.

We exist up in the northwest corner of the United States at a very energy-rich region. The San Juan Basin is known for its natural gas assets and also coal seam. The San Juan Generating Station is one of five coal-fired power plants in probably a 300-mile radius. But we employ about 1600 people in our power plant. And we exist right now in a place where natural gas prices have dropped out of the bottom of the barrel. And our former giant companies that were there providing us with property taxes and employees and wages and benefits, they've moved to other places where producing oil as a byproduct, you get natural gas. And so the basin right now is sitting empty.

Well, then we have San Juan Generating Station, where PNM had said they would operate this until 2033. They implemented the clean coal technology on it, the BART technology to clean up the stakes, and then two years later turned around and came back and said, sorry, we're leaving. 2022, that's when we're going to be out.

We were in a unique position as part owner in November of 2018 to stand up and say, look, we want to stay in this, and we managed to acquire 100 percent of the ownership rights for future operations past 2022. That's a pretty interesting place to be for a municipality. And we immediately, as Jason had mentioned, found a law firm here in Washington, and went out to find a merchant buyer who could possibly find another use for our power plant and our coal mine, keep those 1600 people employed, and help facilitate some economic development and some money that can go in for us to diversify our economy. And that's when we found Enchant Energy.

So it's a unique opportunity as a mayor of a community that has been doom and gloom since 2009. And when the writing was on the wall with PNM closing the plant in 2022, that doom and gloom became even darker. Well, now we have an opportunity to shine a light on an area of our country that is known for energy. It's in our DNA. It's who we are. We provide a quality of life for millions of Americans by providing affordable, reliable, and dispatchable power, and we want to continue to do that, and Enchant Energy has given us that opportunity.

So we're excited about this partnership. We're excited about the future that it holds not just for the City of Farmington, San Juan County, but also the Navajo Nation. Forty percent of the workforce at the coal mine and the power plant are Navajo. If we know anything about the Navajo Nation, 50 percent of those people who live in the Nation live under poverty.

And we exist in a state where 55 percent of New Mexicans are on Medicaid. We're a poor state. Energy is what we have, and energy is what we produce, and energy is what we're good at. And Enchant Energy through carbon capture technology is going to help us continue that history well into the future. So we're excited to be here.

I have brought with me today City Manager Rob Mayes and Farmington Electric Utility Director Hank Adair. They have been integral in leading this charge in negotiations and conversations with Enchant Energy. Hank actually has spent 20-plus years as the engineer manager at San Juan Generating Station, so he has an extensive background and knowledge of that operation of that plant.

So we're excited. I have to say this. There's a lot of synergy right now in our group. We have compiled a very, very powerful team of people to support this project. And I've just been proud to be a head of that and represent my community and the people who live there.

So they're here for any questions that they can answer. We're going to go talk to some senators and try and drum up some support. But I think if I take something from this meeting, I would just like to say that perception is reality. We have to change the perception of the people of the United States as to what carbon capture technology is and what the coal industry is trying to do to address those issues.

There are too many people working out there in our communities, in our cities who demand and need to have these jobs, and communities that are dying off. If you look at a map of America, the rural counties are shrinking, and a lot of those are energy counties. And we have to find a way to support those people who make America strong.

So thank you for the opportunity to be here. This has been an amazing conference for me. I've learned a lot, and I look forward to continuing this partnership with Enchant Energy. Thank you.

(Applause.)

MS. GELLICI: Thank you both for your pioneering efforts. I greatly appreciate that. Do you have time for a question or two?

MR. SELCH: Oh, yeah, we'll take the questions.

MS. GELLICI: A question.

MR. SELCH: But we have to leave because we have some appointments.

MS. GELLICI: Wonderful. So, Vello, if --

MR. KUUSKRAA: Good morning. I really enjoyed your talk, and I was curious as to whether you looked at the economics of 95 or even 100 percent capture. It would, of course, give you more tax credit, more sales of CO_2, and maybe even a better story.

MR. SELCH: So we're actually only using the number 90 percent because that is the number in the literature, and that is also the number that Sargent and Lundy had in their study. Sargent and Lundy was the engineering firm that worked with the Petra Nova plant, and they also are an engineering firm that have worked on previous projects at San Juan Generating Station. So we picked them for their expertise.

MR. KUUSKRAA: Right.

MR. SELCH: They gave us the number 90 percent. From the literature, it's clear that the amount of carbon dioxide out of the stream could be higher than that, that that would consume more electricity. And we just used that number because that was in the study. But I think -- but I agree with you, I think that you could capture more, and the plant is going to be a merchant plant. And as a merchant plant, one of the aspects is that it's going to balance the value of the stream of -- the value of the CO_2 that goes out of one end of the plant and then the value of the electricity out of the other end of the plant.

MR. KUUSKRAA: Of course. There's quite a debate about that going on, and there's some work looking at the incremental costs may not be as high for going to almost 100 percent and thought of in the past. So I was just curious. Thank you.

MR. SELCH: Yes. It's very interesting. In addition to that, on the electricity side, in this area, the electricity price is often extremely low when there's an oversupply in the middle of the day on a sunny day. And so that would be a time when it would make a lot of sense to produce more pipeline quality CO_2 capture, capture.

MS. GELLICI: And for the court reporter, that was Vello Kuuskraa that was speaking, and Holly Krutka now. Thank you.

MS. KRUTKA: Thanks. I was going to do it. But, yeah, Holly Krutka from Peabody. And so thank you both for those presentations, and thanks for your courage in a state that hasn't quite got up to speed on carbon capture probably. I'm just curious if you're -- you're looking at CO_2 sales, but what about PPAs for the electricity?

I mean, do you think that former owners of this plant are going to be willing to buy that electricity, carbon-free electricity? And also, what do you think the chances are of getting carbon capture? Right now, New Mexico has an RPS. What are the chances of getting that converted to a clean energy standard where carbon capture could be rolled into and included in that?

MR. SELCH: Yeah. So we're really looking at the financing of the project based on the CO_2

production and the tax credits. On the front end of the electricity supply, the market in this area is -- as I was mentioning, it has attached a transmission to a number of different states.

These states are all kind of going through flux. We think that the market will want power that is available -- is dispatchable, that is available 24 hours a day, but that's also low emissions power. And that's why I was saying earlier that the coal industry needs to figure out a way that they can change from producing high emissions coal-fired power to low emissions. And I believe that there is a shortage of low emissions dispatchable power in this market and that we'll be able to find the customers when the time comes.

And one of the really excellent things about this project is that the ownership change is baked in in 2022, and that gives us plenty of time to find the customers. And hopefully we will get some of them to believe that low emissions power is something that they want and that they value.

MS. KRUTKA: Okay. Thank you.

MR. SELCH: Thank you, Holly.

MS. GELLICI: Jason, thank you very much. We have time for one last question, please. Thank you.

MR. SNAVELY: Thank you. Charles Snavely, Commonwealth of Kentucky. Could you provide a little color on the securitization part of this and who's paying that and how it affects your economics?

MR. SELCH: Yeah. So that is part of this thing, the ownership change. And I think I mentioned earlier that it's currently owned by a number of different utilities and that they are abandoning the plant. So there's a misnomer in the press, et cetera, that they are abandoning and shutting down.

They're abandoning it. So abandoning means that they have abandoned costs. And in the State of New Mexico last year, they passed the Energy Transition Act, and what that allows is for the principal utility, which is PNM, to take those stranded costs, and they can securitize them, and then it basically means that the cost of transition is decreased to the ratepayers. And that's why they have demonstrated or produced reports to the public saying that the average ratepayer in the State of New Mexico is going to save over $7 a month in monthly bill as a result of their abandoning the power plant.

We're going to pick up the power plant, and we're really not part of that. But I think that it's really the Energy Transition Act and the ability to securitize that allows this transition of ownership to a company that is not a public utility, and it would be a big conversation, but I don't think that carbon capture works for public utilities.

So one of the reasons we're kind of glad to be stepping into this situation is that there's a baked-in transition of ownership, and that is facilitated by the Energy Transition Act.

MS. GELLICI: Thank you, Jason, Mayor Duckett. Thank you both for your participation. As you can imagine, this type of effort, pioneering effort, these folks will have a lot of arrows on your back. But just remember we've got your back too. So we appreciate your efforts. Thank you very much.

(Applause.)

MS. GELLICI: It's my pleasure now to introduce Dr. Ian Reid, who is a combustion technology specialist with over 30 years of experience in gas, oil, and petrochemical industry. Ian has produced studies for the International Energy Agency's Clean Coal Center on lignite power plant technology, on coal beneficiation, and on non-energy uses for coal. He's currently working on uses for coal combustion fly ash.

Ian spent 18 years at BP as a scientific specialist in the invention, development, and design of new technologies. His activities led to his authorship of more than 20 patents in the field of high-pressure oxidation that have relevance to coal gassification technologies.

Ian has a degree in chemistry and a Ph.D. in gas kinetics and modeling from the University of Aberdeen. And he is a fellow of the Royal Society of Chemistry and a charter chemist. We're delighted that Ian has made his way over the pond, as it were, from the U.K. to join us today.

As you all know, we recently completed a report for Secretary Perry on new uses for new markets for coal outside of power generation and steel making, and the report that Ian had produced was a very tremendous reference for us. So we're delighted that he's here to join us today to talk about non-energy products from coal. Please join me in welcoming Dr. Reid.

(Applause.)

DR. REID: Thank you, Janet, and thank you for inviting me to the meeting. I was really delighted that the report from the International Energy Agency was so useful to you in the preparation of your own study.

Let me just find the -- yeah. This presentation is a bit of an overview of the area of new products from coal. It's a very exciting area involving new carbon forms, traditional chemicals, minerals that Brian mentioned, and some environmental applications, and, of course, new materials.

Before I get underway, I'll just mention a little bit about the IEA Clean Coal Center, which is a technology collaboration program with the International Energy Agency headquartered in Paris. We're located in London. And we have a number of member countries and sponsors, including the United States, which is a founder member. And as citizens of the United States, you have free access to all our output.

And, again, before going into these individual things, I thought I would just mention some of the major changes taking place. We're obviously very aware of the geographical shift to Asia of coal use, and that includes coal use for chemicals. Energy electrification is a very important trend. Ground transport is about to take off. And much of the elements and molecules in coal can be valuable for that.

The rising population leading to shorts of water and, in fact, our lands, again, coal can make a difference there, and as well as, of course, increasing demand for all our products.

The steel manufacturer changes are affecting the supply of pitch, which is important in certain products. And the electric arc furnace actually requires pitch products. And then, finally, about natural gas and oil in competition with coal, the comment here is really about the different situation in the United States to, say, China, which has a totally different picture. You're competing at $50 coal or less against -- and you have gas, 125 or maybe even less from what I've been hearing, and whereas, in China, they have to compete with LNG and have no other real natural resources.

The products I'll talk about today -- first of all, I just want to revisit the traditional chemicals and gassification chemicals because of such large changes that are about to take place. I will talk a little bit about carbon fiber, non-carbon materials, rare earth elements and why they're important, carbon electrodes, and the agricultural sector. And there's many others, but I'm also going to mention hydrogen at the end. It's not quite an energy-use product, but I'll cheat.

On the Tar chemicals -- pardon? Oh, closer to it, okay. Sorry. For the Tar chemical industry, that's really the traditional coal chemical industry. And that's gradually increasing demand because many of the products are associated with construction, like phthalates for plumbing pipes or additives for concrete.

But the issue of the steel industry shifting to electric arc furnaces means that the supply of temperature pitch is decreasing, and that's important to many of the other products I will talk about.

The other sector is oxygen-blown gassification of coal. That's largely centered around the methanol-to-olefins industry, making air pollutant plastics. And these two sectors made up that first statement I had about 400,000 tons of coal -- 400 million tons of coal, sorry -- from 100 million tons of products, but is about to change substantially in China. The latest information I have is that there are about 500 projects in stream that will result in around 250 million tons of products that will need three-quarters of a billion tons of coal. And that's roughly the coal production of the United States.

This industry is quite carbon-intensive because, when you make methanol from gassification of coal, you have to reject about half of the carbon as carbon dioxide to shift the product to the methanol proportions. And also, they're going to make a lot of hydrogen for their ammonia business, and that rejects carbon as well.

So that's going to be a major input to the atmosphere. And they are making some attempts, having listened to the carbon capture presentations. There will be a Yulin plant capturing 400,000 tons of CO_2 for enhanced recovery. So that's the traditional industry, but it will have a big impact.

Turning to rare earth elements, we already heard a little bit about them. Just to put it in perspective, neodymium is a very important element for magnetic drives. So a 5-megabyte wind turbine will need about a ton of neodymium. And most electric vehicles will run with permanent magnets, and they will also require it. And if you want to operate above 80 centigrade, you have to add in more expensive rare earth elements, such as terbium, to maintain the magnetic properties.

So that's set against an annual production of about 34,000 tons. And there looks to be a deficit. The economical recoverable resources are quite limited. China is dominant, of course. There are some other deposits, Australia, Greenland, and Mountain Pass Mine in California is restocking. But the issue is that the refining of these rare earth elements is restricted to China and one plant in Malaysia, which is in a lot of problems due to half a million tons of radioactive waste.

China tends to have quite an interest in the deposits around the world, including the new Greenland discoveries. The coal option then has really been driven by United States. There are certain deposits with 3- or 400 PPM of rare earth elements in them, compared to the usual 35 PPM.

The main drives are to recover rare earth elements from waste streams, such as acid mine drainage or coal tailings. And if you follow that route, you can avoid mining costs. So, basically, you're weighing up low-concentrations against the cost of mineral ores.

The final comment is that the environmental record in China is really atrocious. There are massive toxic lake that -- I don't think there's any renovation yet, but it's about 10 kilometers square in scale. They have shot down a number of polluters into that lake, and that has actually affected supply of rare earth elements. And, in fact, since I did the report, original report, on these products, the prices have risen by about 50 percent for these elements.

Now NETL are the main driver for RE from coal, but they're not the only ones looking at it. And this patent from China from five years ago is probably at the start of the program here. And, essentially, what it says is that you can't do the normal mineral refinery process. The magnetic recovery floatation and separation is inappropriate at these low concentrations. So what they proposed was to grind it with a fluxing agent to obtain the rare earth elements.

Similarly, a plan came out from the U.S. using aluminum phosphate as a fluxing agent. But I feel that is the wrong approach because to heat all the coal to get very small amount of rare earth elements doesn't seem right. The picture on the right is Professor Honaker at University of Kentucky's acid leaching and solvent recovery system for rare earth elements. And what it's going to boil down to really is the economics of this recovery.

Moving on to carbon fiber, carbon fiber has revolutionized the aircraft industry. The Dreamliner flying direct to long destinations, it's only possible because of carbon fiber, because of the lightness and the strength. I've put a few figures down at the bottom, about four times the tensile strength of steel from this pitch fiber product, DIALEAD, which is a high-volume product for pitch fiber.

The implications for ground transportation are interesting, though, because the -- to give a price of carbon fiber without any legal implications -- I just got it off the Internet -- $50 per pound, and steel under a dollar. So that's a big gap to make, and explains why electric cars at the moment are refitted with batteries essentially.

But there is a range issue, just as there was for airplanes, on these vehicles. And putting a half-ton battery pack could be compensated for by carbon fiber. Now, $50 against one, yes, but you need less material. So immediately we're down to about a quarter of the 50. And if we can improve the strength of pitch fiber, reduce the cost of feedstock, because, unfortunately, it has risen because of the source of pitch, and also improve the quality of pitch fiber, then that gap could narrow substantially.

But I take a point from Brian that the first applications will be composite materials, you know, reinforced concrete and such like. And that's actually quite a theme in new carbon products for early application.

I'm not going to say too much about electrodes except for this. They've been through a peak in pricing. There was a crisis in the supply of graphite with some manufacturers withdrawing, and a surge in demand. And it takes about three months to make a two-ton graphite electrode and about eight hours to consume it in an electric arc furnace. And so that explains the huge surge in prices.

They are settling, and an expectation that I saw a few months ago is around $5,000, and I saw $4,000 for pitch-type electrodes. Most electrodes include pitch in their manufacturer as a binder, so around 200,000 tons with that alone. But, in Japan, they make graphite electrodes from coal. And the market is set to -- market demand for graphite is set to increase markedly because each factory parking electric vehicle needs about 70 kilograms of graphite. And it's a low-temperature use, and pitch-based graphite might be suitable.

Let's see. Moving on to carbon nanotubes and graphene, when I reported on this, I said, well, carbon nanotubes, which are nano-scale long tubes of carbon, about 1,000 to 1 aspect ratio, could be made from CO or acetylene or other gassification products.

So it might suit a China situation but actually not a direct use of coal.

The interesting thing, though, is that there's already a $2 billion market for carbon nanotubes, which is set to increase, and graphene is a direct competitor material. The difference is that where carbon nanotubes really only have properties in a nano scale, graphene covers all scales. It's at an earlier stage but with more promise. And, essentially, it's just a single sheet of atoms made up of six member rings.

Now I'd like to talk about graphene quantum dots first made from coal. Bituminous coal contains flakes, tiny flakes, of graphite and now the diamonds and things like that because you have crystals of carbon in an amorphous matrix. If you can remove the amorphous matrix, then you're left with tiny fragments of graphene. That can be collected and separated and used for -- well, color filters I have there. And I put this price down here because $50 per milligram compared to $58 for coal. But, actually, it's slightly less than that in reality.

The first -- this work comes out of Rice University, and the company developing it is Dotz Nano in Australia. The first application is to prevent fraud. Quantum dots can be added to a polymer product, and that can then be used to identify the product as being a genuine one. That's a major problem with replication in various countries.

Now that principal of etching away the amorphous coal is essentially the processes that you get to make graphene sheets. There are two methods that are shown here at the moment. The obvious one was the electrochemical route, and there's now a molten salt route.

The problem with them is that a feeling that the application -- the process had come ahead of applications and we're waiting for uses for the material. But they did make a graphene sheet, you know, about this size, and that is a game changer for coal to products.

Some of the applications are amazing, but one of them is relevant to the CO_2 sequestration that was discussed earlier, and that is a group in Lausanne in Switzerland have applied a polymer layer to graphene and are using that as a membrane to separate carbon dioxide. I don't know if that came up in the computer analysis, Brian, but it would be interesting if it did. But it's got some nitrogen flushing to keep the membrane open, which is a critical problem with membranes.

Moving on, there's already an industry that mines natural humate in New Mexico for fertilizer. There's an industry in China that makes potassium hydroxide with lignite, mixes the potassium minerals with lignite to make a humate fertilizer, sells around 700 to $800 as far as I can tell from the Internet.

That product isn't as good as the one I'm going to talk about here, where oxygen is reintroduced into a humate molecule and using what they call oxidated ammonolysis. Fairly mild conditions, but provides a material that would be extremely useful to address acidification. And I don't know if you've been following the UN reports, but last month there was a report about a serious problem in the fertility of our soils due to acidification, drought conditions, loss of carbon from soils. And this is a means to reintroduce it and could be quite a large volume use of lignite

Yes. So I've got a summary slide here, but the essential message from it is the versatility of coal as a potential feedstock outside of combustion. The gas to chemicals in the gassification industry in China is going to be a game-changing scale. Very quickly, it will exceed 1-1/2 billion tons of coal.

RE from coal will depend on the economics of the process, but environmental control is going to be absolutely required in the United States given the history of the industry.

Carbon fiber, yes, I think the key thing for the transport revolution that we're just about to enter -- I read that Ford is exporting only electric car vehicles to Europe in the next period. And, actually, all companies are gearing up to provide electricity. It is going to happen. But steel is not the right answer for these cars for range. But there's a gap in the cost of carbon fiber.

Activated carbon electrodes -- activated carbon is a very nice product to have in combination with the production of pitch for everything else. In new technologies, I think it's graphene, not CNTs, that's going to have most of the opportunities. They're already doing another composite material with graphene to fix holes in roads. They don't last that long. It's a mundane use with a billion dollar price tag. And then humates, of course.

But I'm going to turn to hydrogen now. Hydrogen -- the idea of a hydrogen economy has been around for about 50 years. We've had three or four attempts to introduce hydrogen. But is this the right time for it? Japan thinks so. They're gearing up to put in a hydrogen infrastructure. Toyota and Honda are producing hydrogen fuel-cell vehicles. And the reason is concern over the resources needed for battery packs for electric vehicles. Lithium and cobalt are both in limited supply. The companies are scrambling to get a hold of those resources at an early stage. The problem they have is electrolysis costs far too much. It's more than double the cost of doing a full process, gassifying lignite in Australia and transporting it cryogenically to Japan.

So they're going to cool hydrogen down to 20 Kelvins. And the attraction to Australia, of course, is a completely stranded lignite asset for something maybe familiar to this audience.

The numbers are a bit frightening in that you need for -- the way I've done it is three tons of hydrogen for 100 tons of carbon dioxide emission. And that needs 160 tons of lignite. The numbers are enormous.

Other countries, though, are very interested. China already produced hydrogen from coal in vast quantities, and the plans for the future increase that markedly. And so they're in a position to switch between hydrogen and ammonia. The EU are interested in substituting at least partially for natural gas, a natural gas system with hydrogen. And I think I did some work some time ago where a certain percent hydrogen could be easily accommodated without changing the combustion characteristics very much.

There are hydrogen storage issues, especially onboard vehicles. At the moment, vehicles have to have 700-bar tanks, which are made of carbon fiber composites. But there is work to reduce that to address the economics of the hydrogen system because it adds to the infrastructure cost to pressurize to those levels.

Brian mentioned methyl organic frameworks, and there is research on hydrogen storage involving those, so potential solutions.

So I'm going to stop there, but I hope I've given you some thoughts. There are high-volume uses. There are specialist uses where the costs are a million dollars per kilogram. And so there's the whole range. I think carbon fiber could be enormous, but it needs to narrow the gap on cost.

MS. GELLICI: Thank you.

(Applause.)

MS. GELLICI: I'll ask if there's any questions for Ian. Yes. Thank you, Jackie.

MS. BIRD: Hi. Jackie Bird. Thank you, Doctor, for joining us today. Just you didn't touch on it, so I'm curious about it. At one point, there was research into looking at carbon fibers for electric transmission lines because it would be less electrical resistance and less line loss and therefore improved efficiencies and less cost. Can you address that, or, if it's not in your bailiwick, maybe our NETL brethren can address it.

DR. REID: Yeah. It is true that pitch fiber has got very high thermal conductivity and electrical conductivity. But also, graphene could be interesting in a kind of application because of its properties. So, yes, it is possible, but I'm not sure how much research is going on. Maybe Brian -- Brian's nodding. I think he probably knows.

DR. ANDERSON: Agree.

DR. REID: Yeah, yeah.

MS. BIRD: Okay. Thank you.

MS. GELLICI: Other questions for Dr. Reid?

Outside of technical challenges and cost reductions, are there other -- do you see other barriers or challenges to getting some of these uses, new uses, for coal put in place?

DR. REID: Well, I think that -- yeah, when

I contacted the Graphene Institute, can you make graphene from coal, they said no. So there is some definite perceptions out there that some of these things are not possible. But you can do it. The kind of application that makes for quantum dots, that's a fairly easy application to do. If you want to do medical imaging within humans, then there's going to be medical trials and more barriers.

The coal gassification industry in China is going to more than double within five years. It's an enormous undertaking and shows that, you know, if there is a desire to do it, it can be done. Yeah. And it's a competitor with gas, yeah.

MS. GELLICI: And can you tell us where your future work or that of IEA will be going in this area, what's planned for the future?

DR. REID: Well, yeah. The IEA Coal Center really looks across the piece, but clean coal technologies is at the core of the center. So, you know, efficiency, emissions, that kind of thing. But we are beginning to look a bit further ahead. And the special properties of carbon, the allotropes of carbon, these were completely unknown 20, 30 years ago. It's only buckministerfullerene that's opened people's eyes to the special structures that are in coal. And CNTs have been around for nearly 20 years. They are now a significant market. Graphene, we've known about it for less than 10 years. And applications are coming out. It's the most patented material there's ever been. But, of course, there's a gap between commercializing applications and reception of. Yeah.

MS. GELLICI: Would you please join me in thanking Dr. Reid.

(Applause.)

MS. GELLICI: I'm going to turn the program back over to Tom in a moment for the closing out of our meeting, but I wanted to extend a few thank yous to folks. Danny Gray, chair of the National Coal Council; Randy Atkins, vice chair, thank you both for your support, a lot of extra effort involved. Thank you.

(Applause.)

MS. GELLICI: And I think Horinthia is still outside, so if you'll join me in thanking -- clapping loud for Horinthia and thank her for all of her support. We greatly appreciate it.

(Applause.)

MS. GELLICI: Steve Krimsky, thank you so much for your sponsorship of this event. It's greatly appreciated. We have a number of other sponsors listed on your program, but a big shout out to Steve for your event sponsorship. Thank you so much for that.

(Applause.)

MS. GELLICI: There are evaluations on your desks, if you could kindly complete those. We will also be recycling name tags, and we will be sending you an electronic version of the evaluations. So we would appreciate your doing that.

We are in the process of conducting a new report for the Secretary. Secretary Perry has asked us to provide -- prepare a report assessing technologies in support of coal generation technologies, so what kind of policies can be put in place to accelerate technologies for new coal plants, for existing coal plants that can be put in place.

I would remind those members of the National Coal Council who have been appointed by the Secretary that part of your appointment involves getting engaged. So we greatly appreciate your support. So I learned a new word this week, not volunteer but voluntold. So we will be voluntolding you if we don't hear from you. But please do consider where you can contribute with your expertise.

So, with that, I'd like to just conclude by thanking Tom Sarkus, who is our deputy designated federal officer, for the tremendous job he does. This is a lot of work overseeing a FACA. And, Tom, we greatly appreciate your help with that. Thank you.

(Applause.)

MR. SARKUS: Thank you. It is now time for the public comment period. As stated at the beginning of the meeting, the Department of Energy cares about public viewpoints and wants to hear from you.

In the *Federal Register* announcement that we posted several weeks ago, we offered any party the opportunity to provide a written statement that could be read at this event. We did not receive any written statements. We have also set aside time at this meeting for any individual who wishes to speak directly at the meeting.

As you walked in, there was a sign-in sheet, and nobody on the sign-in sheet requested speaking time. So, at this time, anyone wishing to speak can be heard by raising your hand, and we'll have someone with a microphone come over to you. If there are many individuals who wish to speak, we may have to close the public comment period and ask the remaining folks to submit their comments in writing. And those comments will be included in the meeting minutes as an addendum.

Please limit your comments to five minutes before speaking. Please state your name and affiliation. So let's get started. Are there any people who would like to go on the record and provide comments?

(No response.)

MR. SARKUS: Seeing none, I will move into the closing remarks. Again, thank you, Janet.

It is now time to conclude our meeting. I want to thank everyone for making this assembly a priority and for traveling long distances. We need you to participate. We need you to attend the meetings. Some of you have traveled from across the country to attend and participate, and we really appreciate that. Your cooperation and input have been invaluable in helping to make this a very successful meeting. We look forward to seeing all of you on April 23rd and 24th of 2020 at the Hyatt Regency in Bethesda, Maryland.

This meeting is now officially adjourned.

(Applause.)

(Whereupon, at 12:05 p.m., the meeting in the above-entitled matter adjourned.)

REPORTER'S CERTIFICATE

DOCKET NO.: N/A

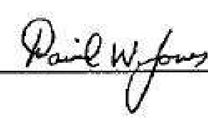
CASE TITLE: National Coal Council Meeting

HEARING DATE: September 12, 2019

LOCATION: Washington, D.C.

I hereby certify that the proceedings and evidence are contained fully and accurately on the tapes and notes reported by me at the hearing in the above case before the United States Department of Energy, Office of Energy Efficiency & Renewable Energy.

Date: September 12, 2019



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