TRANSCRIPT OF PROCEEDINGS

In The Matter Of:)
)
NATIONAL COAL COUNCIL)
MEETING)
)

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BEFORE THE U.S. DEPARTMENT OF ENERGY
OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY

In The Matter Of:)
)
NATIONAL COAL COUNCIL)
MEETING)
)

Board Room
Sheraton Suites - Old Town Alexandria
801 North Saint Asaph Street
Alexandria, Virginia

Wednesday,
April 19, 2017

The parties met, pursuant to notice, at 8:38 a.m.

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I N D E X

P R O C E E D I N G S

(8:38 a.m.)

MR. DURHAM: Good morning. Let's get started. Well, good morning, ladies and gentlemen. My name is Mike Durham, and I'm chairman of the National Coal Council. The Spring 2017 meeting of the National Coal Council is hereby called to order.

This meeting, we are fortunate to have many representatives of the Department of Energy in attendance. I'd like to acknowledge Doug Hollett, Acting Secretary for fossil energy. We'll hear from Mr. Hollett in a few moments in his keynote address.

MR. HOLLETT: No.

MR. DURHAM: No? Okay. You don't have to speak. That's right, sorry.

(Laughter.)

MR. DURHAM: Dr. Grace Bochenek, Director of NETL; Doug Metheney, special advisor to the Secretary of Fossil Energy; Jarad Daniels, Acting Deputy Assistant Secretary for Clean Coal and Carbon Management at DOE; and Jordan Kislear, Director of Government Affairs and Analysis in the Office of Clean Coal, who is serving today as his official federal designated officer. So thank you, Jordan.

I'd like to ask all of the representatives from the Department of Energy and the National Energy Technology Lab to please stand so we can extend our warm NCC welcome to you.

(Applause.)

MR. DURHAM: We have some exceptional speakers on hand today, following Secretary Perry's keynote address. We'll hear from Steve Nelson, chief operating officer of the Longview Power, who will provide an overview of Longview's state-of-the-art power plant.

We've organized our industry presentations around the theme of leading-edge coal technology development. We'll hear from Tony Leo, VP of applications and advanced technology development with FuelCell Energy. Tony will provide us with an overview of fuel cells, a carbon-capture pilot plant, a joint initiative with ExxonMobil.

We'll then hear from David Denton, director of business development at RTI International, who will provide a roundup of the various advance technologies for CO_2 capture and utilization for both power and industrial applications.

And we'll conclude with a presentation with Jared Moore with Meridian Energy, who will provide an overview of the new thermal hydrogen technology concept. We'll then conclude our meeting with council business.

I'll note that this meeting is being held in accordance with the Federal Advisory Committee Act and the regulations that govern that act. Our meeting is open to the public. I would like to welcome guests from the public who have joined us today. An opportunity will be provided for guests to make comments at the end of the meeting.

A verbatim transcript of this meeting is being made. Therefore, it is important that you use the microphones when you speak, and that you identify your name and affiliation.

Council members have been provided with a copy of the agenda today. I'd appreciate having a motion for the adoption of the agenda.

MULTIPLE VOICES: So moved.

MR. DURHAM: Second?

MALE VOICE: Second.

MR. DURHAM: Thank you. All in favor?

(Chorus of ayes.)

MR. DURHAM: Opposed?

(No response.)

MR. DURHAM: Thank you. I'd now like to call on NCC Legal Counsel Julia d'Hemecourt of

Hunton & Williams to provide us with our advisory.

MS. d'HEMECOURT: Hi, good morning. The National Coal Council is a federal advisory committee to the Department of Energy. Membership in the organization confers no immunity from federal or state antitrust laws. As you probably are aware, the NCC has a set of antitrust guidelines. If you would like a copy, one can be sent to you.

During this meeting, we will abide by these guidelines. If you feel we've strayed from them, please interrupt, and we'll make a determination.

Thank you.

MR. DURHAM: Thank you. It is now my pleasure to introduce our keynote presenter, the Honorable Rick Perry, Secretary of Energy. We've included his detailed bio in your packet, but just to highlight a lifetime of service to the country, starting with service in the Air Force, following his college years, to service throughout the politics in Texas, where he's the longest-serving governor in history, and now continues to serve as Secretary of Energy.

So please join me in welcoming Secretary Perry.

(Applause.)

SECRETARY PERRY: Howdy.

It's a great privilege to be here with you today. Mike, it is an honor to catch up and talk about old times. We went to college together. He just looks a lot younger than I am.

Not only does he look younger, but he's always, kind of one of those interesting things -- a very innovative guy, and innovative in the sense of anyone who would name your energy company Soap Creek Energy. I'm still waiting for him to explain that one to me, so -- how he came up with that.

But he's also an interesting fellow in the sense of, he went two years -- he was born in Florida, and then his folks, parents, grandparents, had Texas ties, so he came back and went to school at the beloved Texas A&M for two years. And as he said, they taught me everything that they had to teach me in those two years, and I could leave and go on to Penn State, where he got a Naval ROTC scholarship.

So anyway, we -- the old saying is that you can leave College Station, but it will never leave you. Kind of sounds like a country song, doesn't it.

(Laughter.)

SECRETARY PERRY: And do that, so -- anyway, it's a privilege to be here today as President Trump's choice to be the Secretary of Energy. It was a great privilege for me to continue in my public service.

I didn't come here to do inconsequential things, and I didn't leave our little piece of property there in Roundtop, Texas, you know, just to punch a clock and to serve out a few years in a row. I came to serve a president with a clear and a bold vision for this country. I came to serve my country one more time.

And you might say, boy, there is nothing -- there has been nothing timid about this first five or six weeks on the job, that's for sure. You know, I think it took us like five weeks to get the nomination and the approval of that process and be confirmed. But, it has been quite a ride. It's a most intriguing time.

You know, when you think about what has happened during the last five or six week period of time, you've had a president who signed an order saying that for every regulation added, two has to be repealed. He said that we're going to stop these extremist political agendas from highjacking America's energy needs. And one of the ways he sent that message was by approving the Keystone Pipeline and the Dakota Access Pipeline.

Then he took another important step. The last eight years, we saw a policy driven by political agendas. The problem with some of my friends on the other side is, it's not their utopian views -- well. It's more so how, that they legislate and regulate in ways that are detrimental to the overall well-being of the citizens of this country.

You know, they even came up with some rather nice-sounding names. Clean Power Plan. Who can't be for that, right? Affordable Care Act. Kind of like, you know, their marketing people work overtime. That's all I can figure out, is during the last eight years they had a rather fascinating group of people that were coming up with some cool names.

But what it did had the potential to be devastating to a lot of people in this country. It prioritized carbon reductions at the expense of the American worker. And Americans responded. So with the stroke of a pen, this president began dismantling the Left's war on coal. But there is a lot more work to do. There is work to do in crafting smart, pro-growth policies, like we did in Texas.

I share with people on a regular basis, Mike, that the story over that decade-plus that I had the privilege to serve as the governor of Texas, that we put into place policies that were thoughtful, that were innovative, working with the legislature, working with the private sector.

Texas is the 12th largest economy in the world. I mean, if we were a standalone country, which I remind people on a regular basis that we were one time.

(Laughter.)

SECRETARY PERRY: You know, we'd be the same size, basically, as Russia. And the impact that we have is global. And when, people watch and see what we do.

So tax policy, regulatory policies, legal policies, those matter. They affect people's lives. And we created this climate where people came from all over the country, literally from other places in the world, to live there because they knew that they could risk their capital and have a chance to have a return on their investment.

It's not rocket science. I mean, that's how people respond. Capital goes to where it's welcome. And we saw this extraordinary growth, grew faster than any other state in the nation during that 12-, 14-year period of time, added some 4-1/2 million people to the state, created more jobs.

There was one period of time in that three- or four-year period of time that Texas created more jobs than the rest of the country combined. Four and a half million people, that's a lot of pickup trucks on the highways, non-point-source pollution.

There is a petrochemical refining capacity along that Gulf Coast that's as large as anywhere in the world. And by the way, that happens to be in a latitude that's rather conducive for ozone production, right?

As conventional wisdom would have said, we did a great job of creating this environment where people can come and risk their capital, and they did. But you played hell with the environment. The air, obviously, all of that petrochemical, all of those vehicles that were added to the road, all of that manufacturing growth that occurred.

But here is the fact of the matter. During that period of time, nitrogen oxide levels went down by 60 percent. SO_2 went down by 50 percent. Total carbon emissions down by almost 20 percent.

I ask my friends who may have a different outlook about what the policy should be in this country, wasn't that our goal? Wasn't that what we set out as a people to do, to grow economically, to make Americans' lives better, and to take care of our environment?

See, the point is you can do these together. And I think that's the colliding world view, if you will, between the last administration and the current administration. Donald Trump truly believes that we're going to have, and we can have, economic growth and to take care of our environment.

There are two roads to clean power. Our predecessors chose the road of regulation. They attempted to dismantle the entire industry and destroy jobs according to their very myopic view of how the world should be, instead of how it is.

The other road is to recognize the abundance of the resources that we have, the technologies that make us better at how we produce and use fuels. The Trump administration is for using all of the resources to make America safer, to make energy more affordable, make our air, our land, and our water cleaner. I'm proud to serve with a president who espouses an all-of-the-above energy policy.

I recall vividly sitting across the table from then President-elect Trump. Interesting, it was the first time I had ever interviewed for a job. It was really -- I'm 66 years old, interviewing for a job for the first time in my life.

And he leans across the table, and he said, "Perry," he said, "here is what I want you to do. I want you to do for American energy what you did for Texas." And I told him, I said, "I got my marching orders, sir."

The good news is he repeated that on national television the other day, so you know I'm not just making that up.

(Laughter.)

SECRETARY PERRY: And in Texas, that's exactly what we did. That's the reason we saw those -- both economic progress and the progress on cleaning up the air. Texas cleaned up its air more than any other state in the nation during that period of time. We showed it's possible to lead the nation in oil and gas production, and in wind power as well. We truly had that all-of-the-above.

Wind production was practically nonexistent when I took over as governor in December of 2000. Now Texas produces more wind power than all but five other countries. We recognized that we had a resource, and we created a governance structure around it so that we could use it without sacrificing the reliability our industries and citizens rely upon.

I just saw a recent example of another technology that's helping utilize our natural resources more wisely. We celebrated a ribbon-cutting down, just outside of Houston this last week at the world's largest post-combustion carbon capture system. And it had begun its commercial operation a couple of months ago. It's the PetraNova facility, Richmond, Texas, by that side of Houston.

Anyway, the project, it's designed to capture 1.6 million tons of CO_2 a year from an existing coal-fired power plant. That CO_2 is then used for enhanced oil field recovery in a nearby field, where it is expected to boost the production from around 300 barrels a day to up to 15,000 barrels a day. Pretty good return on the investment, I would say.

The Petra Nova project is showing that CCS can not only make coal plants cleaner, but also can provide a commercially viable byproduct, in this case, the CO_2 for enhanced oil recovery. That is a great example of America's approach to energy. We have more energy resources. We're better at developing it. We're leaders in efforts to make the environment cleaner. I thought that was our goal. And we can do it without sacrificing our economy.

That's why on Friday I asked the Department of Energy to undertake a critical review of regulatory burdens placed on it by the previous administration on baseload generators. Baseload power is critical to a well-functioning grid. Reliable electricity is a critical economic driver.

One of the things I've learned, or I knew already instinctively, but I got to see in practice, is that people will invest when they feel comfortable that there is going to be stability and predictability in a regulatory world. You change the rules halfway through the game, they're not going to invest.

Give them predictability on the tax side, on the regulatory side, on the legal side. Make sure there is a skilled workforce in place. Those are the four things. If you will do those, they will come. They will invest.

It's very true on the grid, the stability, the predictability that that baseload is going to be there. Over the last few years, grid experts have expressed concern about the erosion of the critical baseload resources, specifically how it's dispatched and compensated.

So we're also experimenting, or I should say not experimenting. Well, yeah, hell, I guess we were experimenting, if you want to know the truth of the matter, over the last eight years. But that experimenting also gave us an experience. And the experience is that we're seeing this decreased diversity in our nation's electric generation mix.

These politically-driven policies, they're driven primarily by this hostility to coal. They threaten the reliability and the stability of the greatest electric grid in the world.

As I said earlier in my remarks, I wasn't interested in coming to Washington, D.C. to rubberstamp some previous administration's policies that undermine grid security, jobs in this country, or our underlying economy.

And I have directed my team to develop a study that will explore three critical issues.

The evolution of wholesale electricity markets, including the extent to which federal policy intervention and the changing electric fuel mix challenge our grid reliability.

So whether wholesale and capacity markets are adequately compensating attributes such an onsite fuel supply and other factors that strengthen the grid resilience. And the extent to which regulatory burdens, as well as mandates and tax and subsidy policies, force the premature retirement of baseload generation plants.

So here is the bottom line. We will not sacrifice grid security to appease environmental extremists, nor will we continue to distort the energy marketplace for handpicked favorites. We will use America's abundant resources to ensure grid reliability.

Now, just because we're in the process of ending the war on coal doesn't mean the coal industry isn't without its challenges. There was a war being waged on coal. And while that was happening, technology was making some pretty substantial advances all around you.

We talked about shell exploration and how it literally is now tipping the balance of energy power. The effects of innovation are many, including that while we started building -- you think about this. Ten years ago, there were LNG exports facilities being built in this country. We're now reversing those terminals to sell American LNG overseas.

Mike, I'm thinking -- I think it was in 2005, I was at an event of southern governors, and there was an individual giving a speech on peak oil, that we had found all of the oil there was in the world. And, you know, he wasn't given advice about what the alternative was going to be, but it was like, we're done. You all are going to have to figure out what the alternative --

Well, it's one of the things that I always temper my thinking with, you know, is sometimes they don't always get it right.

The world has changed. And coal has to change as well. As you know, DOE is working to develop innovative and cost-effective technologies that not only can make coal cleaner and more efficient, but it can help support economic growth, energy security, American leadership in the global technology market.

Some of the work is being done at our national labs. There are 17 of those labs spread out across this country. They are an extraordinary asset to our country. They are driving cutting-edge research in this amazing array of scientific fields. This research includes new plant designs, efficiencies, materials, combustion.

It also includes advanced energy technologies and systems that improve the efficiencies through innovation to provide this rich set of options to address our energy challenges and to modernize our coal plant fleet. Other potentials for the captured carbon include feedstock to produce fuels, polymers, fertilizers. And we're working on all of that.

Let me mention one more benefit that the president's all-of-the-above energy policy has highlighted. Underlying the previous administration's war on coal was this radical belief that there is no such thing as clean coal, that literally there is no benefit from the mining of coal, and we ought to get off of it entirely.

Now, President Obama didn't say that. He couldn't. But some of his allies making decisions, that's exactly what their mindset was. And here is why that is and was dangerous. When you declare an abundant resource off-limits because of a political agenda, you close your mind from the scientific possibilities that comes from advanced research. Peak oil.

I'm here to say as Secretary of Energy I will not give favored research status to a few handpicked industries. We will go where the science leads and do what the economy needs. Yes, we will continue to do research on clean technologies, whether they are renewables or how to make conventional sources cleaner. We'll pursue the most promising technologies free of an agenda to distort the energy marketplace.

And here is why that is so important. It is only in keeping an open mind about coal that we can tap its potential. We now know, from a study of U.S. coal ash, that coal mined across the United States, but particularly in the Appalachian Mountains, it holds potential, and tremendous potential, for the development of rare earth elements vital to the advancement of clean energy technologies.

We found elevated content of critical rare earth minerals, hafnium, neodymium, rhenium. Those are all used in the development of new jet engines. We found traces of gallium, which is a vital component in electronics.

Today, those rare earth minerals come in large portion from China. But if we can develop these vital national security products from our own coal ash, it will shift the balance of trade, enhance our national security, and create tremendous opportunity here in America, all because we kept an open mind about coal.

And let me underscore the symbiotic relationship of traditional fossil fuels and clean technologies. In this case, we're advancing clean technology through the scientific process involved in examining the potential of a fossil fuel. When I was in Houston, in Richmond, outside of Houston, the other day, I saw just the opposite of that. We were using CCS, which is a new, clean technology, to pour carbon into an oil field to enhance production of a fossil fuel.

Here is the point. We have to stop this either/or debate in energy. We've got to get clear in our minds and in the public's mind that this isn't an either/or process, that we either choose renewables, or we choose fossil fuels. We can choose both. And when we choose both, we will assist in the development of both.

To believe in science is not so simple as to say you believe fossil fuels contribute to climate change. To believe in science is to allow the scientific process to examine the potential of all sources of fuel, undeterred by political considerations, to find new and amazing uses to improve the quality of our planet.

As Secretary of Energy, I can promise you there are no sacred cows, no most favored energy sources. We will do research in areas where it's most promising. We will let our sources compete on price, and we will live by a simple policy, and that is: we want energy that is made in America for the good of America and American jobs.

The president made one request. Let's just not make America be energy-independent. Let's make America be energy dominant. And we will. God bless you. Thank you.

(Applause.)

MR. DURHAM: Thank you, Mr. Secretary. Good to hear something good about coal.

So let me now introduce the incoming chair, Greg Workman, who will introduce our next speaker.

MR. WORKMAN: Good morning. It is my pleasure to introduce our industry keynote speaker, Steve Nelson, chief operating officer with Longview Power. Again, Steve's full bio is included in your packet. I'd like to highlight a few of his accomplishments.

Steve joined Longview in January of 2014 to manage the plant rehabilitation work with over 36 years of industry experience encompassing the key aspects of power plant operations and maintenance. Steve has extensive experience in generation assets, strategy development, implementation, financial due diligence, program management, maintenance engineering; significant experience also in troubleshooting plant equipment, plant organizations, and aligning the assets' capabilities with key business objectives.

Prior to Longview, Steve -- a deep history -- worked for Sacramento Utility District, Babcock & Wilcox, Pacific Gas & Electric, PPO, Montana, Aptec Engineering Services, as well as Black and Beech.

So without further ado, please welcome Steve Nelson.

(Applause.)

MR. NELSON: Well, I really appreciate being here, and I couldn't have asked for a better introduction than what the Secretary provided. I think he has talked about, you know, he really highlighted a potential bright future for coal, if we look at taking technology to a new degree. And I'd like to highlight that plan in action.

The Longview power plant is a relatively new power plant. It's not necessarily a research project. It's an actual functioning piece of technology that shows the real advantage of what coal can be.

A little bit of background on Longview. We're 778 megawatts gross, 700 megawatts net. We're located near Morgantown, West Virginia, just north of Morgantown, right on the border with Pennsylvania. The plant started operations late 2011, really early 2012. We compete against other PJM coal units that are at or above 45 years of age. So we are the youngster in the group.

The plant was built at a total project cost of $2.1 billion. We firmly believe today with adequate planning and management that it's possible to build this plant again for $1.5 to 1.7 billion.

In 2015, we spent approximately $120 million on the rehabilitation project to correct some construction and slight design errors. The result has been, we are now the most efficient coal unit in North America, and probably within the Western Hemisphere. I'll go into that a little bit more.

Additionally, we have exceptional low air emissions, with minimal wastewater discharge, near zero. We are also the lowest-cost coal-fired generator in PJM, and the driver behind that is the fact that we own our own coal, and we're basically a mine mouth power plant.

The heart of this technology and improvements that we see in coal-fired generation for Longview is our boiler. It's a Foster Wheeler designed advanced super-critical boiler. It is the first of a kind, low-mass flux, vertical tube, super-critical boiler. That means that we have a lot less pumping power to get fluid through the boiler, and thus it improves our efficiency.

This system has worked wonderfully. We've had some issues with the boiler's nose arch, which we remediated in 2015. We took a three-pronged approach in improving this technology in the boiler. We looked at combustion and optimized combustion. We optimized our materials and our welding quality. And then we looked at our circuitry and fluid flow, so kind of a little bit of belt-and-suspenders approach, but it allowed us not only to improve reliability, but also to improve overall combustion quality and performance.

I would like to highlight that we've used some very unique approaches to combustion air control. We've got some wonderful monitoring technology that allows us to run with very low excess air, that helps us with our efficiency. We have to pump less air. It also helps us with our emissions.

Another aspect of the plant, I think a very key one, is that the plant is really a fresh, clean sheet of paper design, and it was, you know, we went down the path of integrating an air quality control system from scratch. That means that we can capture inherently greater efficiencies and achieve cleaner emissions at the same time.

We got improved efficiencies with that air emissions control, but we've also achieved best-available control technology with this approach. Low NOx burners, acid mist reduction, SO_2 removal through FGD, which we now have 99.5 percent removal rate, excellent mercury and HAPs removal.

If we have a challenge at Longview around this, it's measuring mercury. We remove so much mercury that our challenge is measuring it. The one thing that I want to highlight here -- it's a big difference between us and others -- is our post-jet fabric filter or the baghouse. That is a key piece to mercury performance, particulate matter performance, and overall HAPs capture.

The other aspect that's advanced piece of technology is our turbine generator set. This is the global design that's being deployed throughout the world. There is advanced 3D blade design in the turbine. The LP turbine rotors run at an efficiency between 92, 93 percent, which is very high.

It's a very reliable machine. It has a very high ramp rate. We ramp 20 megawatts a minute.

That's comparable to some CCGTs.

We had some issues in a generator initially, some hydrogen leakage, some elevated vibration. Those have been resolved. The other issue that we had to address was our startup fuel.

Back in 2014, during the polar vortex event, we had come down with a tube leak, and we couldn't get back up. During that whole event, we were sitting down, and it was because we couldn't get gas. We were curtailed by the local gas supplier.

So we pretty much gritted our teeth and said that was never again. And so went towards inside-the-fence fuel supply through the world's largest mobile L and G system. We currently, I checked this morning. We have 62 days worth of coal laying on the ground. We also have two to three full startups in these L and G tanks. We are fully independent in terms of fuel.

I think this is a key advantage when you look at what coal brings to the mix, is that we have the ability to operate independently inside the fence.

The thing that was critical for us is since 2014, the capacity performance requirements that PJM puts on us comes with significant penalties, almost enterprise-ending penalties. So the startup capability inside the fence allows us to avoid that risk while providing the best reliability for the grid as a whole.

We also, about a year ago, when gas prices hit very low prices, we realized that we should be burning gas. And we did. We burned up to our maximum capability with the installed equipment, 20 percent of the heat input by natural gas. That gave us about a little bit under 10 percent improvement in our CO_2.

I want to talk about that efficiency a little bit, 8842. That's our all-in heat rate. That was for 2016.

In 2015, we had a little over 9,000 heat rate all-in, and that included a lot of outages, ups and downs, part-load operation. I checked this morning. Our full-load heat rate was 8680. And I scratch my head every day when I see those numbers. How can that be? Well, it is because we have very efficient, brand new, tip-to-tail design.

You know, what does that efficiency mean? It means less CO_2. We are about 20 percent less than the current fleet in CO_2 production. It means less conventional pollutants. It means lower production cost, less landfill requirements, less water consumption. Efficiency matters.

The other part that matters is cost. You know, when you look at this curve, this is the PJM stack. Now I can use that pointer.

Over in here, you see that's primarily wind and water that dispatches first. Then you have the yellow and orange and red, which is nuclear, high-efficiency CCGTs, high-efficiency coal. And then as you go up, you get more coal, older legacy coal, some CCGTs, and then finally peakers. The red dot is Longview.

So we're dispatching with wind and water. That's because of our low marginal cost. That goes with our economic design, having integrated plant. It goes with that efficiency and that low heat rate.

But we also have an order of magnitude difference in our pollutants. You know, more efficient, better combustion, integrated AQCS design, and that baghouse.

When we look at the current fleet as a whole, and then fleet with AQCS that has been retrofitted, and then you look at these modern units, that's an order of magnitude change. This really leads to what the Secretary had just pointed out. There is viable methods of cleaner coal, and that's what clean coal looks like right there.

So it , you know, we look at our byproducts, our water usage. Really again, having that integrated economic design, owning our own fuel, deleting the transport costs, that really allows us to be much more competitive, minimizes the impact to the community.

We look at the water requirements, it's very low. With, again, an integrated design, you don't get that with retrofitting old plants with AQCS. But when you start with a clean sheet, what you end up with is you get everything in balance. And things like water and air emissions, water usage, shows what a clean sheet design does. We discharge about 30 GPM to a mine pool, which we subsequently clean up. But that 30 GPM is not continuous. It's intermittent. So it's a very low water discharge plant.

We also are looking at ways and currently exercising our methods to reuse all our byproducts; bottom ash, fly ash, gypsum. We currently have about 20 to 30 percent being recycled for concrete use, for agricultural use, development of fertilizer, and we're continuing to develop those markets. Our projections is to get to 100 percent reuse of all those byproducts.

I think we should note that when we do things like that with fly ash, if we displace cement with fly ash, it's a one-for-one benefit on CO_2, because it's not just coal plants. It's CO_2 producers. But cement kilns are also a significant CO_2 production source.

So all that, and it's reliable too. We came out of our rehabilitation efforts. We did a 21-day test, and we passed with 99.5 percent equivalent availability factor. We continued that trend throughout 2016, a 92 percent EAF, 86 percent capacity factor. And if the market was better, that would have been in the 90s. When you compare that to the other, newer, modern plants in the U.S., their capacity factors averaged 67 percent.

So that tells you something about how Longview's economic model and its overall efficiency is driving an overall benefit. Again, our 2015 all-in heat rate was 9,009. That won us the Peabody Clean Coal Award for heat rate for last year. When we compare it against an ultra super critical, the only one built in the United States, Turk, it's 2015 numbers was 9,038. And again, I'll highlight what our '16 number is; 8,842.

Our emissions, significant orders of magnitude improvement in mercury as well as PM, and our CO_2 production being 20 percent in the remaining fleet. The other benefit that we've seen through optimization efforts is prior to that effort, the unit had a hard time making full 700 megawatts. Now we routinely make over that amount, 703, 704, up to 710 for days. It has turned out to be a very reliable unit.

Again, this unit is not an exercise in research. It's a result of good research. It is research in practice, and it's very successful. Again, its ability to burn natural gas shows what the future could be with additional upgrades. The potential to burn 40, 50 percent natural gas would put us in compliance with what was the Clean Power Plant.

Again, I really appreciate Secretary Perry, because he kind of pointed right exactly to what economic growth and what impact clean coal can have. We employ 600 skilled workers with very good paying jobs. That's good paying, steady employment, over generations. We look at positive and substantial economic impact to other local businesses, through our purchase of coal and limestone.

We also exercise about $105 million per year of goods and services. That's a real economic impact for our local area. Substantial contribution in terms of monetary and community commitment, through taxes paid and through other community support services.

Again, you know, really looking at Longview; it shows what, you know, an advanced coal combustion technology can be. We think replacing the existing fleet of those 40-plus-year-old plants and looking towards these high-efficiency, low-emissions plants like Longview really shows where we can go, cleaner, more reliable, more effective, more economically viable.

The potential for co-firing gas as well as its increased efficiency allows us to be the best test bed for CCS. Longview was designed to have CCS retrofitted on the back end eventually. There is room back there that was provided exactly for that technology.

So where do we go from here? You know, the Clean Power Plan and the New Source Rule (sic) has done a significant amount of negative impact to coal technology. And it seems like it only has happened in America that we've hobbled ourselves that way. As a result, the current fleet is not really competitive with CCGTs.

It sure sounds like the new administration is intending to roll back those regulations, or to put them in the context where we could actually grow coal effectively through these sort of technologies.

We would like to see a rewrite of the Clean Power Plan to focus on CO_2 emissions and look towards best systems of emissions reductions. You know, we can't really rely on retrofits. I think, you know, I've been around power generation for quite a while, and generally with retrofits, you see less efficiency. You don't see that clean-sheet benefit.

It's because of that that really Longview demonstrates the best systems of emissions reductions, and it should be replicated to maintain coal-fired power in the United States.

So in a bit of conclusion, Longview does demonstrate what a highly efficient, clean-fired, coal-fired power plant in operation can be, with full environmental compliance.

I thank you for your time and consideration of what the future of Longview is presenting. Thanks.

(Applause.)

MS. GELLICI: We will take some questions for Steve.

MR. PALMER: Steve, Fred Palmer with Heartland Institute. Great, great presentation, and congratulations on a fabulous plant.

MR. NELSON: Thank you.

MR. PALMER: With respect to the retrofit question, this aging coal fleet that is 48 years old now and will be 70 years old by 2040, and EIA assumes a steady-state capacity, and they degrade over time, so they have to be retrofitted, period.

MR. NELSON: Sure.

MR. PALMER: How can you do this at smaller scale and get the same results, both from an economic standpoint and also from an emissions standpoint with the iron that's sitting out there now?

MR. NELSON: By doing this, you mean a replacement of units with --

MR. PALMER: Yeah, to retrofit the existing fleet with the technology that you're deploying here on older, smaller units.

Can you do that, or do you have to do a rebuild, a massive rebuild?

MR. NELSON: I think you end up in a massive rebuild. I mean, again, the real benefit that we are seeing here is that, what I call the clean-sheet approach. In having a design that inherently incorporates that, you know, a modern AQCS system; you can only get that through significant gas flow modifications. The steam systems all are coordinated, you know, and the result is better overall emissions with improved efficiencies.

Could it be done, and are there situations out there where you could retrofit an older, smaller plant? Sure. But I think you need to do the math on how much that truly would cost for the benefit you would get.

MS. GELLICI: Other questions?

MS. KRUTKA: Hi. Holly Krutka, Peabody Energy.

That's really impressive, and a really great presentation. So thank you. I'm just curious. I mean, your capacity factor is pretty high, 86 percent. But you're so low on the cost curve. Can you just talk about what would make you ramp down? Because you said it was the market. But what kind of market conditions can make a plant like this ramp down?

MR. NELSON: Really cheap gas.

(Laughter.)

MR. NELSON: We basically are baseloaded pretty much all the time. I would say 97, 98 percent of the time we're baseloaded. But there are cases like a year ago in March, you know, we saw natural gas below $1.80. And overnight, you're going to see really low prices below our marginal cost. You're going to see negative prices. And when that happens, PJM gets on the phone, and they direct us down.

And that's primarily it. Other than that, we pretty much put a brick on the accelerator pedal and don't touch it.

MS. GELLICI: Other questions? You mentioned, you know, being able to build the next plant at a significant savings. Do you see any challenges associated with going ahead again with another new plant, what might be the primary challenges that you see and need to confront? Certainly you've got a lot of the technology worked out at this point.

MR. NELSON: Right. The Secretary hit the nail on the head. It's really investor confidence. It's the question that we asked our investors. You know, we're owned by private equity and hedge funds, and so we turn to them and say, well, what would incent you to do that. And it's just their fear of variable regulation.

That really, if you solved that one and provide, say, tax incentives going forward, I think that makes that a lot easier. Coal has been hobbled. The subsidies given to renewables, the tax benefits and the tax writeoffs that gas can take advantage of and be pretty much capital-free in their financing, that gives them a distinct advantage, and coal has none of that.

MR. BIBB: Bob Bibb, Bibb's Engineers.

I was going to ask this before Holly asked her question, but along the same lines. PJM, you've got a fixed-capacity payment, and then you compete more or less on an incremental-cost basis. And I was wondering how your mine mouth cost of fuel contributes to that overall low incremental cost.

I don't know if you want to talk in terms of dollars a million or relative to other coal-fired plants that ship in coal. But how big an impact is being in a mine mouth operation?

MR. NELSON: Right. Good question. It's really what we've done is integrated the organization. You know, it's vertically integrated. So we get some savings there. But the big driver really is cutting the transport costs. We have a four and a half mile conveyor directly from the mine mouth. That really helps. That's probably a savings in the order of $3.00 to $5.50 a ton. So that really helps.

So it's really a combination of those, that integration and the savings and the transport costs.

MR. ROLING: Dan Roling with Novadx Ventures. My question is along those lines.

For a long time, I always wondered why --

this was 20 years ago when I was naive about why more mine mouth plants weren't built. And then there were utilities that had mine mouth, and they were forced to segregate them for regulatory reasons, where the utilities couldn't have their own coal.

Has the state of the regulatory environment in this country changed to the point where we could replace a lot of the utility-owned fleet with mine mouth facilities owned by utilities and eliminate a significant portion of the transportation; or is the regulation still such, as I think it is in the Southeast, where you're never going to be able to build mine mouth plants and transport the electricity instead of the coal.

MR. NELSON: Yeah, good point. I don't really have the answer to that. I'm not a regulatory attorney, and I don't know that.

The one thing I do know is, being primarily a power plant guy, and now having to deal with a coal mine and a deep mine, that's a different animal.

(Laughter.)

MR. NELSON: My hats off to you guys. That's not an easy thing.

It's a risky venture. And I can see why certain operating companies, generation operating companies, may not want to venture into an area they don't know a lot about.

So that's a new skill set, from a business management perspective. We spend a lot of time managing our coal mine. Thank God we're not spending too much time on our power plant anymore.

You know, but I think to me that's one of the challenges, is that I would not tread into that lightly. Because I'd want to make sure that I had the right mine, the right technology in my mine, I have all the logistics lined up. And then when you start doing that math and then how you site that power plant and the mine together, how does that work?

But, you know, you've kind of asked questions kind of near and dear to my heart, is that I really think that there is a very good thread to pull on around how you get the economic efficiency of fuel extraction to energy conversion. Things like mine mouth, well head, and placing that energy conversion as close as you can. There is great opportunities and efficiencies, both economic and physical, by doing those sort of things.

MR. FLANNERY: Hi, Steve. Dave Flannery with Steptoe and Johnson in Charleston. We love your plant in West Virginia, I should say.

Let me take you to ozone. A Casper update kicks in on May 1 of this year. We have a 70 part-per-billion standard that hasn't yet kicked in. The president has indicated ozone is on his radar screen. We've seen EPA go to the courts and slow down that process of advancing those.

What threat is the next generation of ozone regulation to your plan, if you know?

MR. NELSON: I know, and we're not worried about it.

So we're just up the hill from the Fort Martin plant, a 50-year old power plant. It's really a unique situation that we have. And some of the folks that spend time in Morgantown, and they can both of those plumes from downtown, take a good look at it. You look at that older plant, that plume that comes out of Form Martin has a little bit of a blue tinge to it. You know, that's a little bit of SO_3 and potentially ozone, a little bit of brown from PM and photochemical spot from NOx.

And then you look over and you see Longview, and it's primarily just puffy white, mostly vapor. We don't have any real concerns with compliance to MATs or Casper.

You know, I showed you what our permit

limits were. We easily make our permit limits. We don't struggle to dance on a pinhead to meet those numbers. It's our technologies there.

Again, to that point of the retrofit, can you retrofit this technology in the older units? This is another benefit of having that clean sheet, is that you are going to have a lot less risk about meeting your compliance. Does that answer your question?

MS. DOMBROWSKI: Katherine Dombrowski with AECOM. You talked about needing regulatory certainty in order to have these types of investments in these plants in the future. Yet you guys managed to pull this investment together several years ago. What were the factors that led to this plant being built?

MR. NELSON: There was a desire to get a new coal plant in West Virginia, for obvious reasons.

I think at that time, under that administration, under the Bush administration, there was that window to build these plants. Iatan, Comanche, Sandy Creek, Prairie State, Longview, right? And so there was an overall opportunity. That allowed us to build that, that and capital that was willing to take the risk.

MR. LOPRIORE: Congratulations on your success. And I agree with others, a real good presentation. I'm rich Lopriore, a retired president of PSEG Fossil, and now I'm doing stuff, so I don't know.

Anyways, my question is operational excellence model. You got a very good technology here. Sustainability for the long term is really the answer to any future. Any new plant runs well, in my experience, for five years; and you run around, changing oils, and tweaking things, and all of a sudden stuff starts to go bad.

And really important that the operators don't make human performance errors, mechanics are using the state-of-the-art technology with, you know, using TED, you know, computer-based systems where they can go out and efficiently get their work orders in place.

So my question is, do you have an excellence model that is going to help sustain performance over the long term?

MR. NELSON: That question is near and dear to my heart. Thank you for that.

(Laughter.)

MR. NELSON: That is what I live every day, and make sure that our guys live that every day. And I'm going to crow a little bit here.

Been around a lot of power plants all over the world. I've got the best damn crew on the planet. There is that mountaineer spirit. These guys are good. And they are very, very proud of their hot rod. And they polish it, and they take care of it. And we give them all the technology they need.

The advantages of what was originally built into the plant, and what we did to optimize especially the control system, one thing I didn't mention, is that we removed the Siemens control system, and we put Emerson Innovation system in. And in that process, although the plant already had a significant amount of instrumentation and monitoring, we enhanced it. We did things like the Black & Veatch Asset 360. So we're leaning on them to help us.

We're a single-entity facility. So we're only 86 operating people, so we're lean. You know, you compare us against others, you know, that's a real testimony to our folks.

I'm a stickler for cleanliness. Anybody that has been to our plant will recognize how clean it is. And that's not just because we want to make it pretty. We like that, but what it really does is it gets people connected to the plant, to the plant itself. It also improves safety. We have an excellent safety record.

But when those folks started putting their hands on to physically clean that equipment, they felt the vibration. They found oil leaks. They got intimate with that equipment. And we routinely get people walking up saying, you know, that boiler feed pump, booster pump, doesn't sound right. And then we go into our advanced monitoring equipment, and look for the facts, and dig up what our threats are.

Our topic twice a day is, what is our threats to generation, and we look forward. It was one of the biggest challenges I had when I first got there, is that I had a workforce that was very, very good at reacting. And we needed to change that. We needed to make them proactive and look forward. And they do that, and they do that very effectively.

MS. GELLICI: We have time for one last question here.

MS. SULLIVAN: Hi. Vicky Sullivan with ACCCE. Thanks for your presentation. It was fascinating. And congratulations on recycling 20 to 30 percent of your solid waste and trying to get to 100 percent.

My question has to do with another set of regulations that we in the electric utility industry are dealing with, coal combustion residuals and F1 limitations guidelines. Do you see those regulations having an impact on your facility and operations going forward?

MR. NELSON: Yes, potentially. Again, I'll go back to that thing of being proactive.

You know, we're being driven on an economic basis as well as a community benefit to get that recycling increased. And we believe if we continue down that path, that's the best hedge we can against those sort of regulations.

One advantage we've had is that our landfilling occurs on a dry basis. It's not a slurry. that helps us. But overall, we're not too concerned as long as we stay proactive about finding places for our residuals, useful places.

MS. GELLICI: Steve, thank you so much. It was an incredibly wonderful presentation. Thank you.

(Applause.)

MR. DURHAM: Thank you, Steve. We greatly appreciate your presentation, very engaging discussion we had afterwards as well.

So thank you again to both of our keynote presenters this morning. We're now going to be taking about a 30-minute break, reconvene here at 10:15. I have official Apple time of 9:46, so it's actually a 29-minute break.

MS. GELLICI: Sorry. I noticed there is a few of my NCC members in the back. We do have some seats that have opened up in the front. If you'd like to move up, I invite you to do so.

Thank you. We'll see you at 10:15.

(Whereupon, a brief recess was taken.)

MS. GELLICI: Thank you.

I'd like to kick off our industry presentation session this morning. I think we're off to a great start. That was a very rousing session this morning, so I appreciate everyone coming back. I know you're all energized, as am I.

But more great things to come here yet this morning, so I'd like to again kick off our industry presentation session this morning by introducing Anthony Leo, Vice President of Applications and Advanced Technology Development with FuelCell Energy.

Tony is, as I said, with the Advanced Technology Group. That group develops fuel cell carbon capture. And that group is also working on developing next generation products, including the solid oxy fuel cells used for hydrogen production and other programs such as advanced fuel treatment and evaluation of alternative fuels.

Tony joined FuelCell in 1978 and has held key leadership positions in RD&D and commercialization of technologies during his tenure there.

He served as the Chairman of the American Society of Mechanical Engineers in their Fuel Cell Performance Test Committee. He holds a bachelor of science degree in chemical engineering from Rensselaer Polytech Institute.

Would you kindly join me in welcoming Tony Leo. Tony?

MR. LEO: Good morning.

I'm going to talk about a unique way to do CO2 capture from coal plants or from other flue sources using a carbonate fuel cell power plant.

The first couple of slides I'm just going to tell you a little bit about my company. If I can figure out where to aim this. There we go.

So FuelCell Energy manufactures, sells, installs, services power plants from 1.4 megawatts to 3.7 megawatts based on carbonate fuel cell technology, a technology that is now commercial, but that was in fact developed with a lot of Department of Energy Support in the 1990's and early 2000's.

We like to think of ourselves as being in the energy supply, recovery and storage. Supply, of course, from power generation. A couple of recovery technologies, in addition to carbon capture, is recovering energy from natural gas pressure let-down stations using carbonate fuel cells, and also purification of dilute hydrogen streams using some of our other electrochemical technologies.

And we're looking at using our solid oxide based fuel cells for things like hydrogen generation, hydrogen-based energy storage. But I'm going to focus on the carbonate fuel cells and their application in carbon capture today.

A little bit more about the company. We are based in Danbury, Connecticut, about an hour northeast of New York. And about an hour northeast of Danbury, which is our corporate headquarters, is our factory in Torrington, Connecticut. So those fuel cell stack modules are built in Connecticut and essentially exported.

Our main markets are North America, Europe, and Asia, specifically South Korea. And I won't go through them all, but you can see, this just shows a list of our customers behind the meter and in front of the meter as well as strategic partners and investors.

So a little bit about what fuel cells are, and then I'll show you how they can be used in CO_2 capture.

The picture all the way at the left shows a fellow who's actually holding a fuel cell. And fuel cell is a thin sandwich. It's a fuel electrode that consumes fuel and makes electrons. It's an air electrode that consumes air and also consumes electrons. And when you hook a wire between those two, that's power. And between them is a thin layer of electrolyte, and that electrolyte can be a variety of different things. In our case it happens to be based on alkali carbonate, potassium carbonate, sodium carbonate, those kinds of things.

So he's holding an individual fuel cell, and behind him there are 400 of them stacked up.

So that individual thing he's holding makes a little less than a volt. So you've got about 350 volts or so in the stack behind him.

And in our standard fuel cell package, we put four of those stacks inside an enclosure, and that's a 1.4 megawatt fuel cell module. That's what it nets after conversion from DC to AC and feeding parasitic flow.

We use one of those modules in our 1.4 megawatt system. Two of them go into our 2.8 megawatt system. And we now have a 3.7 megawatt system that uses a third module. That third module runs off leftover fuel from the first two, so it achieves about 60 percent electrical efficiency. So it's like a natural gas combined cycle type efficiency, but at a distributed generation size.

And it's targeted for a lot of the emerging non-CHP applications. Most of our units are deployed in combined heat and power applications.

So that 3.7 megawatts is the biggest thing we make, but customers do do bigger projects and they do it by, as you see on the bottom there, just putting multiple units at a site.

So this is a little bit of a view of what a typical 2.8 megawatt fuel cell power plant is.

As I said, it has those two fuel cell stacked modules. Each of them is netting 1.4, so it's 2.8 megawatts total. And the mechanical equipment, which you see in the middle of the system, which we call the MBOP, mechanical balance of plant, is just heat exchangers, air supply, blower, startup, heater, that kind of thing.

The electrical equipment, which we call the EBOP, electrical balance of plant, is DC to AC power conversion. Because direct current is what comes out of a fuel cell. It's like a big battery. And switch gear and so forth for interface with the grid.

So that's a complete system that takes pipeline quality natural gas or bio gas and converts it to electricity.

So I'm going to get a little bit into how it works, because it's kind of important to explain how we can use it for carbon capture.

As I said, all fuel cells, they're like batteries. In a battery you have a chemical at one electrode that makes electrons, and another chemical that consumes electrons, and an electrolyte salt bridge between them that completes that circuit. In our case, that's a carbonate.

So what happens at our fuel electrode is hydrocarbon fuel, typically methane, is converted to hydrogen and that hydrogen is reacted to make electrons.

Meanwhile, at the air electrode, air is being consumed and it's consuming those electrons. And as I said, you hook a wire between them and that's your power.

What's unique about the carbonate fuel cell is that the ion transfer that completes that circuit is based on carbonate ions. And as a result of that, there's extra CO_2 produced in our fuel electrodes that needs to be recycle back to the air electrode where it's consumed.

So for every molecule of methane we send in, a molecule of CO_2 is going to go out the chimney. When you're in the fuel cell business you can't use stack, because it gets confusing. So a molecule will go out the chimney.

But in addition to that one molecule of CO_2, four extra CO_2s are produced in the fuel electrode and recycled back to the air electrode where they're consumed.

And the key to the high efficiency is this is an electrochemical process. You have varying fuels to make electricity mechanically. You're avoiding some of the emissions from high temperature combustion.

But the key for carbon capture is that little CO_2 recycle, which is pretty inconsequential for power generation. But what we realized as we started to do this work, is that if you interrupted that cycle, if you took most of the four CO_2s that are coming out of that fuel electrode, you would need to provide some other CO_2 from some other source to the air electrode, because it needs them for its reaction.

And that source could be the flue gas from a coal power plant or some other combustion source.

So the idea is that you could literally use this fuel cell for carbon capture.

And as we got into the work, and DOE has been supporting this work for a few years right now. As we got into the work we found another benefit which is that if you send a flue gas with NOx into our air intake, as that NOx flows through our air electrode for a variety of mechanisms that it took us a while to figure out, about 70 percent of that NOx will be just destroyed, just flowing over the air electrode catalytic surfaces. So that's a nice side benefit.

Plus, as you see in addition to all those CO2s, there's four waters that's produced at the fuel electrode, and so it's a net water producer, this system. And that's an additional benefit in a lot of areas.

So the application for carbon capture is kind of shown schematically here. You basically take our standard fuel cell stack module and you add some stuff to the balance of plant that allows you to extract the CO2 that's coming out of the anode.

And the key is that you're trying to capture CO2 from a pretty dilute source. Depending on the fuel, something like 5 to 15 percent CO_2, it's hard to capture and purify.

But when you flow that into our air electrode it gets electrochemically pumped from that dilute stream to a much, much smaller stream, our fuel stream. So when it comes out of our fuel electrode, that fuel exhaust gas is leftover fuel, about 70 percent CO_2, and the rest is mostly hydrogen. It's very easy to separate the CO_2 from that stream.

So essentially, the fuel cell while it's making electricity, is acting as an electrochemical pump for the CO_2. And it's that co-production of electricity while you're doing carbon capture that enhances the economics. Because instead of taking a 500 megawatt coal plant and adding a carbon capture system on it that converts it to a 300 megawatt coal plant, you're taking a 500 megawatt coal plant and you're adding 300 megawatts of power generation to it. So it's like a whole different type of economics.

So the applications are pretty much what you'd think. Capture from large-scale coal systems, capture from natural gas plants, capture from industrial processes; boilers and so forth.

And one interesting application is capture for enhanced oil recovery, because you can actually, you can think in terms of having systems that are actually at the oil production site running off associated gas producing CO_2 that can be used for enhanced oil recovery out on-site. So a little bit interesting sort of distributed CO_2 production for EOR approach.

So as I said, the Department of Energy has been funding the R&D for a few years now. We have done small cell testing to identify exactly what impurities do to the fuel cell; the types of materials that you would see in a coal plant. We have done stack testing, so-called bench scale testing.

And now we're moving on, doing the first megawatt scale demonstration.

And this is going to be at a coal plant, at the James M. Barry electric power generation plant right outside of Mobile, Alabama. It's Alabama Power Southern Company's plant. And there's about two gigawatts of generation there, roughly half and half coal and natural gas. We are going to connect to the coal exhaust and take a slip stream, of course, because we're just going to do one 2.8 megawatt plant.

We're going to capture 90 percent of the CO_2 from a stream that's equivalent to about three megawatt's worth of coal generation. And it's going to be the first megawatt scale demonstration of this technology so we're pretty excited about it.

So the DOE program has been focused strictly on coal, and in parallel we've started a development effort with ExxonMobil to look at capture from natural gas sources. There are some differences. It's a lower CO2 level, probably a hotter exhaust. And it's possible that after we do the DOE demonstration on coal, it's conceivable we could use that same pilot for demonstrating the natural gas technology we're developing with ExxonMobil. But they're two separate programs basically.

And so as I said, it will use one of those 2.8 megawatt systems that I showed you. We have to modify the BOP to add equipment to extract the CO2 from our anode exhaust and pressurize it and liquify it, and that's what we'll be basically doing at that site.

So that's a stepping stone to what we all see as the ultimate goal, which is large-scale systems that are capturing lots of CO2 from very large-scale coal plants.

And this is a picture of a system that we've been designing under the DOE program. It's a 350 megawatt system that will capture 90 percent of the

CO2 from a 550 megawatt coal plant which is kind of a base design plant that we're using in the program.

And I showed you the four stack module that our current products use to achieve this kind of scale. It's more economical to look at very large multi-stack modules. So these stack modules have hundreds of stacks in them instead of just four, to make it more compact.

So because of the low cost of the fuel cell equipment and the fact that you're generating a revenue stream of power, the cost analysis that we've done and we continue to do, indicate that we're on track to meeting and doing better than the DOE targets of $40 a ton or two center per kilowatt hour cost addition.

Again, it's the coal production of power that makes this an attractive way to do carbon capture.

So this is where we think the technology and the application goes. This is the home run. This is what we're working for.

But what we've asked ourselves is in the meantime, as we're developing this technology, are there near-term applications that we can use kind of to help us get down the road with this technology.

And so one of the things we've thought about is, well, what if you took one of those 2.8 megawatt plants and modified it for carbon capture and actually put multiples of those the way some of our customers do, what we call fuel cell parts.

And you could start to think about doing either carbon capture from a smaller system, from a thermal system, or incremental carbon capture from a larger system. This happens to show 12 of those units that would be capturing 500 tons a day from a coal flue. Plus it captures its own natural gas fuel. These are fueled by natural gas, so we have to capture 90 percent of the CO2 that's in the coal flue plus 100 percent of the CO2 that we're introducing from the natural gas.

So this system, for example, will produce 700 tons per day of CO2, and that's probably too little to think about sequestering. It's definitely too little unless there an actual ongoing well. But it's not a bad quantity of CO2 to think about for finding an industrial CO2 off-taker, like an industrial gas company or a specific user.

So this could be one way that we start to get this technology out into the marketplace as we move forward toward that very large-scale vision.

So finally, just to wrap up, this is a really interesting technology, primarily because of that co-production.

It utilizes this commercially available fuel cell technology with modifications to the balance of plant systems. So it's, the electrochemistry is exactly the same in carbon capture as is in operation in hundreds of power plants around the world.

It's modular, lower cost. Primarily from the co-production of power. I mentioned the NOx construction as an additional benefit, water production.

And I can't stress, this was invented in the U.S. with a lot of DOE support; manufactured in the U.S. And it's great to see, you know, we got some DOE support for the core technology, commercialized that. That was a real success story, we think, and we think we're on track for another success story with the same level of support in this new step in the technology.

So the last thing I'd like to do is just acknowledge and thank DOE and NETL for their support for the project and for their guidance. And open it up to questions.

MS. GELLICI: Okay. I have one question. Is this heavy? It looked like it was something that is very feather-light.

MR. LEO: One of those four-stack stack modules weighs about 100,000 pounds.

MS. GELLICI: Oh.

MR. LEO: So it's heavy.

MS. GELLICI: So, but the guy can lift one panel easily?

MR. LEO: That cell is not heavy. The individual cell is not heavy.

MS. GELLICI: Okay. That's the non-technical question. So now we can turn it over.

Does anybody have a question? IF you do, please raise your hand. Hiranthie is coming around with a microphone. Please identify yourself.

MS. JOHNSON: Hello. My name is Kim Johnson.

You mentioned in addition to being fueled by natural gas it could be fueled by bio gas. Is there a specific BTU content that you need when you're fueled by bio gas?

MR. LEO: Well, one of our early markets, about half of our systems in California are fueled by bio gas. Mostly used for wastewater treatment centers, but also breweries. And so, when we saw that market, we basically said that we need to sort of size our pipes and so forth for what would be a typical bio gas level, and the answer is about 500 BTUs per cubic foot.

MS. JOHNSON: Thank you.

MR. FASSBENDER: Alex Fassbender, EcoVia.

Just to follow up on that question about bio gas, did you have any concern about silane? Or do you take that out with the balance of plant?

MR. LEO: First of all, I'm surprised at two bio gas questions at a coal meeting.

(Laughter.)

MR. LEO: But the answer to the question is, we take sulfur out. That's the main thing, we look at that because that can poison some of the colloids in the fuel cell. And the systems we use to take the sulfur out take all the siloxanes out. So we've never really had a chance to see what siloxanes would do to the fuel cell.

They won't do what they usually do, because there's no combustion in there, so they won't make silica and screw up stuff that way. But in any event, we clean them out kind of incidentally.

MR. NELSON: In the exchange in this process, what's the impact of stack life? And is there a change in stack cost?

MR. LEO: So far the stack life actually is increased when we do this, and the reason for that is that if you're trying to do 90 percent carbon capture, remember, CO2 is a reactant at the air electrode. And usually we leave the air electrode stream with four or five percent CO2.

If you're trying to do 90 percent of the carbon capture from a 5 percent CO2 stream, you're leaving the air electrode at a very low CO2 concentration. So at that point we actually dial the current entity down a little bit, and everything we've seen so far shows that that actually increases the stack life.

But if you're running at exactly the same current density, I don't think there'd be an impact on the stack life at all.

MR. THOMPSON: John Thompson, Clean Air Task Force. Great presentation, and thank you.

There was a paper, I think, that touched on your technology. It was kind of a case study in Canada, Lingan Plant, if my memory's right. And I think that had some EPRI, you know, cost numbers.

I'm wondering, do you feel that that, those estimates of that technology of yours on that plant would represent what you, you know, think it might be today or tomorrow, or are those too high, too low? Do you have a sense on that?

MR. LEO: I'm trying to remember the specific study. There actually have been a few studies done in Canada, primarily supported by the oil sands people. A couple of them have used Jacobs Engineering. Some have been more near-term focused, and some long-term focused. And generally speaking, the costs aren't far off from what we would expect.

MR. THOMPSON: Okay. Thank you.

MS. GELLICI: What is the timeline on the plant, Barry, project?

MR. LEO: We recently decided on that site. It took us a while to find that site and finalize the site access agreement. And in rough terms, we're going to spend about a year of engineering, engineering that modification for the BOP system that I talked about and doing site engineering and permitting. And then a year, give or take, for the building. So it's about, a little bit less than two years.

MR. ALI: Sy Ali with Clean Energy Consulting.

I know you were active in the late '90's on solid oxide fuel cell projects. What has happened to that?

MR. LEO: We're still active on solid oxide fuel cells. Give another shout-out to DOE. We have a DOE-supported project, which is looking at ultimately large-scale solid oxide systems running on coal.

MR. ALI: Right, a hundred megawatts plus.

MR. LEO: And in the near term we're looking at doing systems that are 200, 400 kilowatts in size as a demonstration of that technology, but the possible commercial products.

So we're still definitely very active in the solid oxide.

MS. GELLICI: Tony, thank you very much for a wonderful presentation.

Our next presenter is David Denton, who is the Senior Director of Business Development for the Energy Technology Division of RTI International. In his work in this capacity, David helps to identify and drive new government and industry sponsored business.

He was employed for a number of years at Eastman Chemical Company, which is where I got a chance to meet you many, many years ago.

David received his BS degree in chemical engineering, our second chemical engineer I guess this morning, from Virginia Tech, and did subsequent graduate work in chemical engineering at the University of Tennessee. He holds several U.S. and foreign patents and has also presented expert testimony before the U.S. Senate Committee on Energy and Natural Resources.

He's a fairly new member of the National Coal Council, so we're delighted that David is able to join us in multiple capacities here today.

So would you please join me in welcoming David Denton. David?

MR. DENTON: Thank you very much, Janet, and thank you for the opportunity to speak today.

Just as an intro to RTI, in case you don't know who we are, you may have known us as Research Triangle Institute, now RTI International. We're one of the largest research institutes in the world, about $900 million of annual research at RTI with 5,000 total employees, about half of those located in the Research Triangle Park area of North Carolina. But we do work in approximately 75 different countries.

Our Energy Technology Division is focused in these six main areas. We started in looking at clean coal and syngas processing work. Expanded that into these other areas of carbon capture and utilization, biomass conversion, natural gas, extraction and conversion of advanced materials, and industrial water treatment.

We focus primarily on this gap of the space between the basic concepts and taking things into where industry will pick up the technologies and move them into the commercial space.

We partner with public entities, with academia, and with a number of industrial clients. You see some of those indicated below.

The EIA still indicates that coal is going to remain a significant portion of the world electricity generation for the foreseeable future, and that doesn't include the chemicals to, the coal to chemicals and fuels applications that are primarily in China at this time.

And even though short term or near term we may see some diminishment in some of the drivers for the need for carbon capture, we still believe that long term global issues are going to drive the ultimate reduction of carbon emissions from the use of coal.

And to ensure that coal remains competitive in that kind of an environment, current carbon capture costs are just too expensive. They need to come down, and DOE has set some goals as well as to where they'd like to see that driven.

When you look at where the cost comes from conventional route means for carbon capture, over half of it's from power. Most of that is from the reboiler duty for the regeneration of the solvent systems that are used. The next biggest hunk, about a third of it's from the capital contribution of the equipment, and about 11 percent from operations.

So when you look at any pathway to reduce that cost ,you need to focus, obviously, quite a bit of effort on that regeneration energy, that reboiler duty, what can you do to reduce that.

What can you do as well, on the capital requirements. Looking at things such as efficiency. Simplifying the process arrangement and lower cost materials of construction. And in doing this, trying to keep those operating costs in line as well.

Here's just a few examples of some of the current state of the art of technologies that are out there. The first world-scale, large world-scale boiler, carbon capture system, was the SaskPower Boundary Dam unit that's been operating a little over two years. Now about 5,000 tons per day of capacity in terms of its carbon capture at 90 percent. It uses more traditional Shell Cansolv amine type process for it.

You heard this morning about the PetroNova project. In fact Secretary Perry was there for the ribbon cutting last week, but they've actually been running since about January of this year. They use one of the more advanced amine systems from Mitsubishi Heavy Industries, what's called their KS-1 Amine System. That also is about the same capacity as the SaskPower system, about 5,000 tons per day.

One of the biggest ones that's out there being not ready yet to capture, I don't think, but it's close, is the Kemper County IGCC project. That will capture almost double the amount, almost three million tons per year, of CO2 when that is operational.

The one thing here is it uses the Selexol system from UOP for the carbon capture, and that has been demonstrated at very large scale around the world for gasification for chemicals, mainly ammonia and those type of processes. So we really expect that that carbon capture technology will work at that system when it is up and running.

There are a number of new sort of leading the edge advanced technologies under development. A whole bunch of them, as you see here. This is a chart from DOE NETL.

We've looked at a number of these ourselves. We think that there are quite a few of them that do hold some promise. The ones most that are most promising to us are the advanced solvents, physical and chemical solvents, solid sorbents, the biomass cofiring to carbonate fuel cells we just heard about from FuelCell Energy, and some of the chemical looping technologies.

All these technologies, of course, will take some time to develop and get into the marketplace.

RTI has been working a number of years in this area. We have some very innovative solutions ourselves. Looking at carbon capture from industrial sources such as fossil fuel power, cement, chemical facilities.

We've focused primarily on a couple of areas. Non-aqueous solvents and solid sorbents, but we've also done some work in the space of chemical looping systems, membranes and hybrid systems.

We're showing some real progress on those systems, with the potentials to reduce that regeneration energy penalty by as much as 50 percent against monoethanolamine. Reduce the overall cost of electricity when you're doing carbon capture by 10 to

12 percent compared to DOE baseline studies. And reduce the CAPEX for that carbon capture block also by as much as half.

You can see here on the chart, for example, this is the KS-1 Amine System for the PetroNova project. This is standard monoethanolamines. This is the kind of regeneration penalty we're seeing for the non-aqueous solvents that we're looking at.

This work has been done in partnership with the U.S. Department of Energy, but we've also worked with a number of other government agencies. Some of them outside the U.S., such as the Emissions Reduction in Alberta, Gassnova in Norway, and the Masdar institute in the Middle East, and also with a number of industrial clients.

The solid sorbent project process is for flue gas, the post-combustion one. It's based on an immobilized polyethyleneimine in a nanoporous material in the fluidizable position. That one has shown already potential for a greater than 25 percent reduction in the cost of CO2 capture with potential of as much as 40 percent cost reduction.

It has about a 40 percent energy reduction on that regeneration energy versus the standard monoethanolamines, a high CO2 loading capacity of about ten weight percent, a relatively low heat absorption.

One of the problems in a lot of the conventional solvents is their aqueous based which means when you're trying to take something out of a flue gas not only are you capturing the CO2, but you're capturing quite a bit of water moisture from that a well. Which then when you go to the regeneration step and you have to boil that water back out, that's a pretty heavy heat load that you have.

This is a four-year cooperative effort between RTI, Masdar, and Department of Energy. This developed it to the pilot scale and we've been testing now in Norway through this year on bench scale and small pilot scale systems.

The status of it is it's ready to go to a larger pilot scale with potential for commercialization in the 2020 to 2025 time frame.

This shows the unit that was done for testing at the NORCEM's Brevik cement plant in Norway. That testing was done last year. Most of it's completed. A little bit of it's going on and following it up this year.

In the phase two it has shown the kind of potential that we saw, were hoping to see for the materials.

We've also looked at pre-combustion in terms of sorbent systems and have developed one that works at 400 degrees centigrade for capturing carbon dioxide from syngas. This one's not as developed as the one I just showed you with the post-combustion sorbent, but it does handle the high temperatures. Experimental work to date on bench scale systems, small pilots have shown the technical feasibility of the process.

The one that we have, perhaps that I'm most excited about, is the non-aqueous solvent system that I mentioned. Because they're non-aqueous, it gets around that issue of the water absorption that I mentioned. They also reduce the energy penalties as much as 50 percent against monoethanolamine.

Keep in mind, the KS-1 is about a 20 percent reduction that's out there. There's a Hitachi H31 I think it's called, that's about 30 percent reduction. This is about a potential 50 percent reduction. So it's really pretty exciting. It also reduces the cost of electricity associated with the capture and reduces the carbon, the capital cost significantly.

This system is now in pilot stage of testing at SINTEF in Norway. It's a really good cooperation between RTI and Linde and SINTEF, and with the two government agencies, the U.S. and Norway governments working together to move this forward and accelerate the technology development.

This shows the unit in Norway that's being tested, the large-scale system that has the ability, we believe, to duplicate and give us a good indication of commercial performance. Part of it's to compare and benchmark it against standard amine systems in this unit and in our system.

If I had to report the work to date, testing's been completed on the monoethanolamine system that showed really good comparisons against the reported commercial regeneration heat loads for the system, which gives us a good indication that what we see from our system will also be indicative of commercial performance.

And those initial results are very encouraging. We're seeing the kind of suspected or projected reductions that we were hoping to see, the 40-50 percent reduction in energy reboiler duty against the amine systems.

The next step of this will be to actually do a large pilot scale pre-commercial unit in the one to ten megawatt scale. Right now we're looking at that potentially to be done at the Technology Center

Mongstad in Norway, but it might be at the National Carbon Capture Center or other locations here in the U.S.

This carbon capture system also has potential for pre-combustion, particularly if it's coupled with a warm gas cleanup system like we showed at Tampa Electric for removing the sulfur out first. And that's one advantage, is that technology enables other systems that might not have been considered for pre-combustion work to be considered now.

The advantage is it's both a chemical and a physical solvent, so it has good performance at low pressure for flue gasses, things like that, but as you go up in the pressure for a gasification system, it gives you enhanced potential capacity, almost about a 30 percent, 25 to 30 percent extra capacity at the higher pressures that you might see for gasification.

I want to just briefly mention an actual demo we did at Tampa Electric Company funded by the Department of Energy that used an amine, activated amine system coupled with a warm syngas cleanup system.

That syngas work was done, finished in April of last year. It's actually now available for commercial license. It involved an innovative process where you have a fuel transport loop system that takes a sorbent around that takes the sorbent around, that takes sulfur out at high temperatures up to 600 degrees centigrade, and you can couple that then with back end carbon capture, technologies that you might not have been able to do before.

This shows the actual demo site. It was a 50 megawatt demo, handled about two million standard cubic feet per hour of syngas at Tampa Electric. The warm sulfurization process and advanced water gas shift process. It also worked on, and then this BASF activated amine process.

What we showed was that the warm syngas cleanup did a thousand to one reduction in the sulfur straight through at the high temperature. We also demonstrated that the water gas shift used about half the steam that conventional systems have used. And when coupled with the final back end carbon capture, we saw another 100-fold reduction. So almost a 100,000-fold reduction in total sulfur across the system.

This was a petcoke firing system, so coming in at about 10,000 parts per million; going out at something less than a quarter of a part per million.

The carbon capture system that was employed there was this BASF activated amine system. It was not possible to use this kind of system with pre-combustion systems before because it's non-selective relatively between sulfur and CO2. But since we're able to take the sulfur out at high temperatures ahead of it, we could utilize this system for the carbon capture.

The results of the carbon capture process performed as expected. The carbon capture efficiency was 99 percent, greater than 99 percent, and we achieved the greater than 90 percent carbon capture goal that we had.

The primary impurities in the CO2 were low. The biggest one was hydrogen, about one mole percent. We saw trace levels of CO, hydrogen sulfite and COS.

The combination of those two systems does provide carbon capture with a reduction in low life cost of electricity. Overall IGCC CAPEX per kilowatt and OPEX per megawatt hour, and a 75 reduction in overall sulfur emissions versus a conventional dual-stage Selexol type system.

And what we found is that this coupling of the two, when you decouple the two, it enables the overall process of cleanup and carbon capture to be reduced, depending on the system, by as much as 50 percent in CAPEX, and as much as 50 percent in OPEX across that whole block of the syngas clean-out.

Those two processes are actually both now commercially licensable from Casale SA, if there's interest.

When you look at the, you've captured the carbon, what to do with it when it comes to the storage or use of the carbon dioxide, safe storage is still being proven. It has been demonstrated now in several places. It does still face some legal and regulatory risks that need to be addressed, and various policy measures.

But there's some really good innovations in CO2 utilization that may provide some new avenues for beyond CO2 storage. I want to talk about those just briefly.

These are all the things that captured CO2 could potentially be used for. The problem is, with all these you're going up the energy curve from a low energy state to a higher energy state, which takes energy input to utilize that CO2. And about the only conventional technology that's commercially using CO2 is the urea process, taking ammonia and CO2 to urea. But all these have some potential if you had a way to somehow lower the barrier or find another way to offset that extra cost. And that's the approach we've taken.

We've started looking at some avenues that might offset that cost and still have a viable process route.

We developed a novel catalyst that actually extracts some oxygen off the CO_2 at very low, relatively low temperatures compared to existing technologies that were out there. It enables then, opens you up for some avenues of oxidation reactions, including things like dry methane reforming and ethylene diethylene oxide, and that's the one that's actually shown here, where you take ethylene diethylene oxide, also produce carbon dioxide which is also a very useful molecule in the industrial space.

When you look at how that works, how do you make this viable? If you look at the process for the, using this catalyst system for the oxidation of CO_2 and compare it against the conventional ethylene oxide process. And to make the CO then you also need a steam methane reforming system or something like it.

Where you start seeing the process simplification is that one, you don't need the air separation plant anymore because you're extracting the oxygen off the CO_2. You eliminate the CO_2 emissions from the ethylene oxide process, because you're now going to recycle that back to your feed stock coming into the process. You also eliminate the bulk of what it requires in terms of steam ethylene reforming for carbon monoxide formation.

So when you look at all the pieces of that process that start going away you find that, a couple of things. There's one other one that's a safety thing. The ethylene oxide process has some explosive potential because of high exotherm, but you're now replacing that highly exothermic process with one that's a moderate endotherm, so that helps on the safety issue as well.

And overall, you find that in current ethylene oxide processes, this does look like a viable technology. And you also have the CO, carbon monoxide, as a valuable intermediate. And it's able to reduce a significant amount of CO_2, almost three tons of CO_2 reduction per ton of ethylene oxide product, and about a 350,000 ton per year ethylene oxide plant to reduce CO_2 emissions by about a million tons per year.

The other thing we like about this is that it has a large volume of chemicals, so it can consume some significant amounts of carbon dioxide.

Closing thoughts. Coal will continue as a key feed stock for worldwide energy, but we believe that there are drivers still to look at carbon reduction from the use of coal. There are several large-scale projects that are out there now demonstrating that carbon capture can work. But to keep it competitive, we believe the costs from those technologies need to come down.

There are a number of advanced technologies being developed. You heard about a couple of these today. Some of the ones RTI is doing, FuelCell Energy as well, that are being developed and look like they have real good potential for bringing some of those costs down.

The safe storage of CO2 is being proven, but still faces, as I mentioned, some legal and regulatory risks that need to be addressed through policy. And some of the innovations in CO2 utilization offer some very interesting technology and business options beyond the CO2 storage.

With that, I'd like to acknowledge the RTI Energy Technology team, the U.S. Department of Energy, and the other project partners that we've had as we've looked at this.

With that, I'll conclude and take any

questions.

MS. GELLICI: Thank you.

So when I first invited David to speak I said what can you talk about? And he said well, I can talk about this. I said oh, that sounds good. And he said, and I could talk about this, too.

So we went on like that for about five, ten minutes or so. So, obviously RTI's doing a lot in terms of technology development so I think you get a good sense. And that really is what we wanted to convey as well. It's just incredible, the amount of work and activity that's going on and this is just representative of one company that's doing so.

Questions for David, please?

MR. BIBB: Bob Bibb, Bibb Engineers. Great presentation, and overwhelming, as I think Janet was alluding to. So the broad thing is, there's lots of things happening and lots of different options and lots of different approaches.

But underlying all that, this technology has been marked by extremely high auxiliary power, high cost. Aside from the process. Are some of these providing a breakthrough in those areas?

MR. DENTON: Yes. In fact that's the biggest thing we are addressing.

If you look at that pie chart I showed earlier that showed about 56 percent of the cost of carbon capture was from power. It's the auxiliary power requirement you just mentioned that's involved. About another third is from the capital reduction.

So with, for example, the non-aqueous solvent I was talking about, that has the potential to reduce both of those two pieces of the pie by about 50 percent. The regeneration of energy penalty coming down about 50 percent. The capital cost about 50 percent. So that lowers the overall total cost of carbon capture in the range of 40 to 50 percent. So, to me, that's pretty significant, compared to where we are today.

And the thing that I wanted to point out, not so much our cost in this, but there are several other areas of looking at this and there is some real potential to start bringing that cost down pretty dramatically.

MS. GELLICI: David can you, while there's a question, while Hiranthie is making her way, you know, we talked a lot about development in these technologies, and then trying to get them to the commercial stage. It sounds like, you know, some of these are there. I wonder if you could just talk a little bit about some of the challenges that you've encountered in trying to get to that commercialized stage.

MR. DENTON: Yes, it's definitely a challenge. People have talked about the valley of death, that, I think we heard that some earlier. That to get these technologies from that idea stage into commercial reality. There's quite a bit of cost that's involved. There's time that's involved. You have some really interesting things going on. RTI, for example, a non-profit institute, so we don't have a lot of deep pockets to fund that kind of thing going forward, that's why the partnership with industry and with private/public entities is really important for us.

I think it is something important as you think about the future of these technologies, how do we get them into the marketplace? Because, you know, we've got several now that are at the pilot stage looking quite attractive. That next step, though, is not a small step, to go up to a few megawatts and demonstrate these things. And the investment that's required is significant.

That's one of the reasons we've been reaching out across a spectrum to a number of companies. We've also looked outside of the U.S. to Norway which does have some pretty interesting funding mechanisms for this type of thing. We looked at cooperation, in this case, between two governments -- the U.S. government and the Norwegian government -- to help accelerate that.

So I think we'll need to look at creative ways to move these things forward, but there is a real issue, a real need.

You'd hate to see a promising technology die on the vine just because there's not a mechanism to move it to the next level.

MR. THOMPSON: David, great presentation. And Janet, you kind of touched on my question topic, so let me expand it a little differently.

My question was also on the valley of death. I've been struck with how powerful the national Carbon Capture Center and Mongstad together kind of help you with, at least with respect to solvents move through that valley of death because there's equipment that can take you from TRL-1 all the way up to basically 7 or something, you know, just with those two things.

But, and it's amazing just how many solvents have kind of moved through that system. But we don't really have a similar thing, at least I'm not aware of, that allows you to do that with say pressurized oxy-combustion or other kinds of advanced systems.

If you were king and your word were law, how could you create, what kind of similar mechanisms that could de-bottleneck those movements from TRL-1 to 7, much like Mongstad and CCC does, that we could apply to these other areas of carbon capture or carbon reduction through advanced power systems?

MR. DENTON: Good question.

I think the key that's made them work is the fact that you have put a lot of infrastructure in place that a lot of other companies don't have to duplicate.

Otherwise, if you're doing each of these as a one-off type of project, you're adding quite a bit of additional investment to each of those situations. But where you've already captured the flue gas or syngas and have the piping there, you have the infrastructure of the systems, you have the ability to do something with CO2 potentially afterwards, that starts nipping away at that cost, starts lowering that cost threshold for it.

In terms of the systems you mentioned, you're right. There's not a lot that exists there yet. You would have to find an appropriate site that had such a gas stream for the treatment and look at doing something similar, putting in through some means the kind of infrastructure that lowers those costs for moving it forward.

MS. GELLICI: David, thank you very much. We appreciate that presentation. I think a note to self for me is to learn more about what's going on in Norway. It sounds like some innovative things going on there.

I'd like to conclude our industry presentation session with a presentation by Jared Moore, who is an independent energy consultant based here in Washington, D.C. In his consulting practice, Jared provides advisory services on technology and policy related to decarbonization.

Jared invented and developed thermal hydrogen, which he'll be speaking about today, and an emissions-free energy economy that can be fueled mostly by hydrocarbons without necessarily requiring carbon capture. Kind of skipping that.

He's published in multiple peer review journals. He is also a contributing author of a book on variable renewable energy and the electricity grid.

He has a BS in mechanical engineering and a PhD in engineering and public policy from Carnegie

Mellon University.

Would you please join me in welcoming Jared Moore. Jared?

DR. MOORE: Thank you for the introduction, Janet. Today I'm going to be introducing a vision for economy-wide decarbonization that's fueled mostly by hydrocarbons, but only 10 percent of the hydrocarbons require CCS.

It is a hydrogen economy, but pure hydrogen distribution is not required whatsoever.

Not surprisingly, the committee thought the big challenge for this presentation was one, fitting it in 25 minutes; and secondly, its relevance to the coal industry, especially in the short term. So let me just get that out of the way right now.

Coal I view as a solid hydrocarbon, and as such, coal has three fundamental problems. It has a portability problem; it has an efficiency problem; and an emissions problem. That's versus the other fossil fuels, too. So there's competition.

The three principal chemicals in this pipeline system that I'm envisioning are syngas, O2 and CO2, Those would solve the three fundamental problems of coal. So not only should coal have a place under deep decarbonization; coal might be able to thrive.

And furthermore, so for the short term, you know, this isn't just a pipe dream. In the short term, what I'm going to show you at the end and the point of vision is to see where you're going, and then know what the next step is tomorrow.

So my vision calls for increased electrolysis, and I'll show you that even if coal-fired power plants fuel with this electrolysis, it would decrease system-wide emissions. So it's a marginal gain in the short term, and it's a step towards a vision in the long term.

Now before I get started I'd like to mention one more thing, and this I'm sure you've heard before. I need funding. So I'll just say this about that. Andrew Carnegie said, pioneering don't pay. That's what I'm doing. I still think it's worthwhile.

So I'll go ahead and get started.

Let's talk about the fundamental problem we're looking to solve, the so-called planetary emergency. And most people think the problem is the creation of CO2. It's not the creation of CO2 per se. It is the creation of CO2 that is diluted with nitrogen. It gets diluted with nitrogen because we combust fossil fuels with air. Air is 80 percent nitrogen, so the products are 80 percent nitrogen, at least.

So this necessitates a gas separation problem, also known as work; and that requires both capital and efficiency. Those are two steps in the wrong direction. So there isn't a question whether CCS is technically feasible. You know, it's a willingness to pay problem.

So this system on the right, that's post-combustion carbon capture and sequestration; and the system on the left is pre-combustion carbon capture and sequestration. A gas separation problem, but it's before combustion instead of after.

And here's a quote from, this is my roommate in grad school. I owe much of what I know about CCS to him, if not everything, and he described CCS as being about gas separation either before combustion or after.

So about, after I spoke to you guys last time, and that was in November of 2015, I pretty much made up my mind as an engineer that we needed a low carbon liquid fuel in order to reach deep decarbonization. So I was studying water separation, hydrogen production, and I realized two things.

First of all, electrolysis is endothermic.

That's a minor point that will come into play later. But the second point is, it creates pure oxygen. And I was reading this report from General Atomics, and it says something about selling the O2, and I just thought wait a minute.

That quote from my roommate went through my head. And that is what thermal hydrogen is. Thermal hydrogen is using the O2 that comes off, the pure O2 that is a result of water or CO2 splitting. It is a liquid, let's just say water/CO2 splitting, and then a combined pre-combustion process.

And it doesn't necessarily need to be full oxidation. It can also be partial oxidation. In that instance we have a new chemical energy carrier. It is advantageous to do partial oxidation. So that's why I'm showing that as well.

So this is the formal definition of thermal hydrogen. This is what I came up with in December of 2015, and basically what I've been doing since then is engineering an economy-wide system based upon this principle.

So let's talk about economy-wide decarbonization. It's not just electricity. There's three different energy services and that's what I'm showing here in italics. Electricity, transportation, and heat.

To provide those three energy services, we need three different energy suppliers. And I'm showing this as renewables, nuclear, or hydrocarbons, or as I like to think about it in my mind, mechanical power, heat and chemicals.

And this is important, because at the bottom, you know, we're going to, this is how this is going to shape up throughout the presentation. The bottom is chemicals. The middle across the way is heat. And then the top is, you know, mechanical electrical. It's not storable.

So in order to provide these services, we need devices to convert the energy into usable energy. And these devices I'm showing you, these are the major capital requirements. And they all require capital and energy. There are energy losses in every one of these boxes.

So, you know, people think that the modern grid can only be improved with the right price signals, but there's a lot of improvement in our modern economy. We burn, one-third of our energy comes from oil. Oil is set by global demand. It's going to be perpetually expensive compared to the other fuels. We burn it inefficiently in internal combustion engines.

Furthermore, we also have the redundancy problem here, and after 120 years in the electricity industry, we still haven't come up with a fundamental mechanism for providing capacity.

Did you guys know that the NRG CO just recently said to his own shareholders, our business model is obsolete. I'm not quoting him verbatim, but that's essentially what he said. He said I want to reiterate my belief that the IPP model is now obsolete. That's what he told his own shareholders in prepared remarks. He blames low commodity prices. That's going to be important later on.

So what people would like to do is basically replace this turbine with a battery and then replace all of this infrastructure with a battery as well.

I showed you guys this graph last time, and this basically shows the problem with storing energy with a battery. If you do it seasonally, you're only using that battery a few times a year. If you did it diurnally, it would be every day. So whenever you see a storage payer they always choose the diurnal time scale, of course. But on the seasonal time scale it looks silly.

Today I'm adding two new services,

transportation demand and heating demand. And those don't make the problem better, they make it worse.

So batteries aren't only just impractical for long-term storage, they're impractical for transportation.

What I'm showing you here is four different conduit cord options, essentially, with increasing electrification. At the top here, this is just your standard internal combustion engine. Extremely inefficient. This is your Accord hybrid with gasoline. This is a fuel cell using hydrogen. And this is a plug-in hybrid. This is a story you would expect, right? Increasing efficiency, increasing efficiency.

But the end of the story is when we get towards deep decarbonization. We actually provide range with these batteries. And as I'm showing over here, the Tesla Model S requires 90 kilowatt hours to just go around 300 miles.

That battery at $200 per kilowatt hour is $18,000. That's about a car by itself. And not only that, that battery has an effect on efficiency. You see that this pattern didn't hold. It should be right over here, right? There's no excuse for the Tesla Model S to be less efficient, other than its massive battery, than the Honda Accord plug-in hybrid.

The Tesla is an all-aluminum car. It has one of the most aerodynamic frontal areas in automotive history. It costs, it starts at $70,000. But it weighs 750 pounds more, and it requires 30 percent more energy.

So whereas battery electric transportation isn't as efficient as people say, hydrogen transportation isn't as inefficient as people say. You see, you notice that this has a battery. That's because all fuel cells produce electricity. And it just makes sense once we're producing electricity, once we have an electric drive train, to just have a small battery there. It's for regenerative braking and assisting in acceleration.

So if efficiency is desired, what we can do is increase the size of the battery. We don't need to increase it very much. Just enough to provide 30 miles of range and the acceleration of the vehicle. That require ten kilowatt hours. Ten kilowatt hours would provide about 175 horsepower.

So at that point what we can do is have a plug-in fuel cell hybrid. This would have a 10 kilowatt hour battery and about a 10 horsepower fuel cell. So, the reason that fuel cell can be so small is all it's doing is keeping the battery charged and providing heat occasionally. So it's enabling increased efficiency by reducing the weight of the vehicle and not forcing the battery to produce heat.

So if you look at these two, they're the same efficiency. So this idea that fuel cells are so inefficient compared to battery electric transportation; it's just not well thought out.

So coming back to our economy that we would like to decarbonize, this is kind of as far as we've gotten. We know we need batteries for transportation to some extent. We know we need wind and solar, nuclear. And we know we need CCS. We still haven't come up with a mechanism for load following demand.

So because we're having such a problem with low electricity prices, here's what I suggest. Instead of trying to sell into that commodity market and doing load following supply, why don't we start buying from that market and do load following demand?

So basically what I'm suggesting is reversing this arrow and turning this into an electrolyzer. So what an electrolyzer is, from an engineering economic perspective, pretty much the opposite of what a natural gas combustion turbine is.

A natural gas combustion turbine, you buy a chemical, you put it through a cheap device, and you provide timely electricity. An electrolyzer buys timely electricity, puts it through a cheap device, and produces a chemical. But this chemical can displace oil. So that's very important. Plus, there's a side chemical: oxygen.

And you notice there's another big difference here. When we provide load following supply, nitrogen is involved in that process. Nitrogen is not involved in this process. Oxygen is created. So that means we have carbon abatement instead of a carbon problem.

And you might be thinking all right, well that sounds, I'll think about that later. You know, I was pretty quick. But the thing is, you probably have been thinking this whole time maybe that it doesn't make sense to make hydrogen from electricity. There's heat loss. I agree. But the thing is, you don't need to create hydrogen from electricity. You can also do heat-assisted electrolysis.

You know, this nuclear device here, it's got to go through a turbine or it goes through an electrolyzer. If it goes through a turbine it's losing 50 percent of its heat. If it goes through an electrolyzer it loses 25. But it can only supply about half of it.

So half comes from electricity, half comes from nuclear, and it's the same 25 coming out. Heat assisted electrolysis.

So now you're saying well, it's not going to be as efficient on the other end because when you use hydrogen there is waste heat.

Well, the primary purposes of hydrogen is to provide heat-related services directly. And furthermore, it's to provide range. And lastly, combine heat and power.

So what I would like to -- if you don't remember anything else from my presentation today, I want you to remember this. Not only do electrolyzers provide oxygen for pre-combustion CCS, hydrogen is not just a battery.

That's the way Elon Musk has described it. He says hydrogen is stupid because it starts from an electron, it goes towards a chemical, comes back to an electron, and he even specifically said, "dump the O2."

None of that ever happens in this economy. It is a heat to heat exchange. That's why it's called thermal hydrogen. Hydrogen, if it's a battery, it's a battery for both electricity and heat. If you think about its potential that way, it can be just as efficient as a battery, if we have some heat generation.

And of course one of the major points here is to use that oxygen. And what I'd like to point out here is that hydrocarbons, as far as I know, can't get any more efficient than burning pure oxygen. If we use oxygen for complete combustion, it can create pure CO2. The CO2 goes directly into the turbine, also known as the Allen cycle, and it is 65 percent efficient if it doesn't have to provide its own air separation. You know, what's going to be more efficient than that?

In auto thermal reforming, it's called auto thermal reforming because it doesn't have waste heat.

So not only does oxygen engage the CCS process, but it also improves the efficiency of hydrocarbons.

So now that we have produced pure CO2 coming out of both of these processes, we don't necessarily need CCS, but I think CCS is very useful, so I'm going to later show you how to use the nitrogen from CCS. But for right now I'm going to save that for the distribution section.

So this is what thermal hydrogen is overall.

This is what's on my business card on the back. So if you guys -- sometimes I've presented this and people will take a picture. So I just decided to put it on the back of my business card. So if you'd like to pick that up, please do.

But this is, you know, I've got a specialty in thermodynamics. I don't know where the waste heat is in this system, so I challenge any scientist to come up with a system that has less waste heat. And you might be able to do that, but I'd be really hard-pressed if you could do it and be less capital intensive. That's what I don't think can be done.

So, you know, this is quite technical, and this is in the paper, by the way. Janet didn't mention this, but this work has been peer reviewed by the International Journal of Hydrogen Energy. I just approved the proof on Saturday so it's going to be public and accessible next week, or this week, as far as I know. Next week at the latest. So this has been peer reviewed.

So what I'm going to do since this is going to be documented in public quite soon, I'm just going to go through these results and show you guys the highlights.

Now, this is a Sankey diagram of the entire economy. And I'm just going to highlight three important facts from it.

First of all, only 35 percent of electricity used in this economy goes towards electrolysis. The excess electricity on the grid is around 50 percent. That's how much excess steel and copper we have out there. That's the average capacity factor for all the generators in the entire U.S. economy. So 35 percent seems like a reasonable guess, or a very reasonable estimate for what would be available out there.

And the other thing I want to show you is that 80 percent of the hydrogen comes from heat-related sources. From hydrocarbons, and then heat-assisted electrolysis from the nuclear.

So it's not only coming largely from heat, it's going largely to heat. This is combined heat and power. This is just combustion. And this is providing range. Lowering the heat loss through rolling resistance friction. So that's what that's for.

And also I should point out, there's just as much dispatchable capacity in this economy as is necessary for the current grid. So we could accommodate a large amount of renewables in this system.

So this is the cost estimate that I did for the paper. The reason I had to do that previous economy is because I needed to do the oxygen balance to figure out how much hydrogen came from the electrolysis side and then how much hydrogen came from the autothermal reformer side.

As you would expect, the autothermal reformer is much, much less expensive, and the electrolyzer is a little more expensive. And these are standard assumptions that I got from an NREL Workshop last fall. And there's room for improvement in these costs, especially if you use a ceramic electrolyzer like I'm going to talk about in a second.

But I think that basically what I'd like to impress upon you is that electrolysis is not dominating the cost here. It's fossil fuels. That's why, you know, this is the combined cost, the 30 percent electrolysis, 70 percent autothermal reforming. And as you can see, the costs are spread, and it's pretty low, around $1.50. So that would correspond to around $1.50 per gallon as far as energy is concerned for gasoline.

So let's go back to that chart I showed you earlier with the, you know, very large battery, and these are the cost assumptions given a sensitivity analysis. And one of the features of having so many different, you know, components to rely upon is if one of them gets more expensive, it's not going to kill the economics of the entire system. So there's reliability through diversity. So that's why this cone is so small.

So just, you know, I need to move quickly, but this is the only, this in the only part in this chart that doesn't require an extraordinarily large battery, is emissions free, and has low fuel costs.

So this slide shows you how much energy is required for a thermal hydrogen economy versus the modern economy.

And this is what I just showed you, the balanced economy. This is an economy dominated by nuclear. This is an economy where nuclear is not allowed. This is what I call the organic economy. This is what I think will ultimately come to fruition.

The organic economy is basically, you know, these are hydrogen economies. The organic economy uses ammonia and syngas. And the reason it can be just as efficient as those other economies is because we're not having to compress so much hydrogen. And I also think it will be more economic because hydrogen compressors aren't free, obviously, and obviously it's going to be very difficult to even get these.

A hydrogen gas station is a challenge. Let's just put it that way.

So this is the vision for enabling hydrogen energy carriers.

First of all, we electrolyze CO, so I'm envisioning us electrolyzing CO2, you know, in the middle of the country and piping that towards the autothermal reformer which would be near the city center. That gets turned into hydrogen through the water gas shift reaction which is a sub-reaction in the autothermal reformer.

So this autothermal reformer creates pure hydrogen, and the calculation I did for the paper was that it would only require about 70 gigawatts of CCS; the nitrogen from 70 gigawatts, to turn all combustible hydrogen into ammonia. It's because CCS is so productive at producing nitrogen and ammonia only needs one N per three hydrogen atoms.

So that can, you know, ammonia is basically envisioned to replace natural gas. To replace gasoline, we're not going to let autothermal reforming go all the way. We're going to only use about half the oxygen, and that's going to create syngas, basically.

The advantage of syngas is if you just put it through a catalyst it could be turned into methanol. Methanol is a liquid at standard temperature and pressure. So then it can be transported exactly like gasoline and even better, it can be blended in gasoline. So it kind of helps to solve the chicken and egg problem.

So you're saying okay, what do you do with that carbon? Well, it's going to come back to that thing I said earlier about this being a nitrogen dilution problem.

The tank is filled with methanol. The methanol is turned into syngas using waste heat off the solid oxide fuel cell.

The solid oxide fuel cell, what's unique about a solid oxide fuel cell is that it's an additional air separation unit. Oxygen crosses the electrolyzer, not hydrogen. So when oxygen crosses the electrolyzer, what's created is carbonated water.

So without nitrogen dilution, this is going to be a very small product compared to the exhaust coming out of your car. Not only is it twice as efficient, it's missing 80 percent of the product.

So this is carbonated water, and I envision this just filling up the other side of the gas tank, and then when the methanol tank drops off its fuel, picking up that carbonated water and bringing it back to the autothermal reformer for sequestration.

So the advantage of this is not only have we eliminated the hydrogen distribution problem and we've decreased our need for oxygen, which decreases our need for water splitting, we've also created water.

And so if we use enough syngas in solid oxide fuel cells, the entire energy economy could be a net producer of water. But it depends. It depends on how much water shale gas requires, and it depends how much water cooling of the power plants requires. But it's possible. It's a step in the right direction.

So finally, the point of doing all of this visioning was to show you the immediate steps. So what I've done here is I've moved the existing infrastructure out of the way. This is what we use for transportation. These are all legacy plants, I'm just putting them over here. Here's what we now we want, wind and solar batteries. We're kind of unsure. At least there is not enough public support for anything else.

And so the first step here, because electricity is so cheap and we've got an over-supply, is to start an electrolyzer. So that would create some hydrogen, but the key here is to use the oxygen. The oxygen would allow most of the fuel to come from natural gas. So that's how it can be less carbon intensive as an overall process, even if coal is what produces this.

So even though coal produces some of this, most of the energy is coming from natural gas, and then it's used twice as efficiently as an internal combustion engine. So that's how it can have lower emissions.

So our immediate goal is to displace oil, and then our medium term goal is to get off the internal combustion engine. And here's what, I need to mention this to you guys.

The methanol can be mixed with gasoline up to 30 percent, and actually the automakers are asking for it because it increases the octane rating on the fuel which allows a higher compression ratio which allows higher efficiency.

And another great thing about solid oxide fuel cells is they can reform any hydrocarbon.

So people that had a solid oxide fuel cell car would not have to worry about a range problem, because they could use gasoline. And by the way, Nissan has already developed a solid oxide fuel cell vehicle, and I should have mentioned this earlier, it has a 25 kilowatt hour battery and it has a 7 horsepower fuel cell. And it's for a minivan.

So that's our immediate goals. These are our immediate goals. And eventually we decide what power plants to retire and then what power plants to add CCS to.

And then, you know, around 2045, let's say, high temperature nuclear reactors come on-line so then we can do this heat-assisted electrolysis process. Then once all those pipelines are in place, we can decarbonize combustion.

And then in the end, you know, eventually, you know, 2075, when I'm 90 hopefully, all of the existing infrastructure will be gone and we'll have this economy. And you know, one more thing, this economy doesn't consume oil. All of the CO2 that's produced can go to EOR.

Rick Perry called for a dominant energy vision. How could you get any more dominant than not using fuel and exporting all of your fuel, and then taking CO2 and adding more to that. I don't know how you could have a more dominant energy vision.

So in conclusion, this is an emissions-free, oil and water producing economy fueled mostly by hydrocarbons. These are the most efficient hydrocarbon pathways possible. It's the most efficient and direct route for nuclear.

It's the highest utilization of electricity, and I'm saying that because these are ceramic electrolyzers. They don't require precious metals. So that could allow the largest opportunity to buy electricity because these electrolyzers can take on a low utilization problem.

These are the lightest weight, fully electric vehicles possible. The demand following options -- and I guess I forgot to mention why I named it demand-following, but that's because everything in the economy has an option. Anything capital intensive has an option to follow demand. And, you know, if I had more time I'd explain to you why gas storage isn't required, but essentially what is possible is to store ammonia and methanol seasonally. We don't even need to store gas seasonally.

Lower distribution cost, because we've minimized the need for copper. There's no purer H2 distribution. And we're looking for an edge in manufacturing. Well, I think these pipelines would probably pay for themselves. Syngas being ubiquitously available for cheap, along with oxygen and CO_2, you know, what better advantage could a manufacturing industry have than living in the Saudi Arabia of everything and using energy the most efficient way possible?

So finally, I can't quantify this, but supply and options are always good, and I think this economy provides all of those. So with that, thank you for, you know, trying to listen to all that complex technical knowledge, and I look forward to your feedback. Thank you.

MS. GELLICI: Thank you.

So I can only imagine what your grammar school volcano science project looked like.

(Laughter.)

MS. GELLICI: Wow. Okay, is anybody brave enough to ask a question?

We have another engineer asking.

MR. SCHOENFIELD: Thanks, Jared. It was very interesting. It's going to take a while for me to wrap my head around your end vision, but I have a question about one of the intermediate steps.

You talked about the blending methanol with gasoline. Is methanol as hydrophilic as ethanol is? And have you thought through what the impact would be on existing, especially small engines: lawn mowers, outboards, generators, refrigeration systems, things like that.

DR. MOORE: It's a real simple answer. No.

(Laughter.)

DR. MOORE: One of the words I don't know what you're talking about, so apparently my volcano project wasn't that impressive.

You know, my roommate from grad school, Kyle Baurget, he now works in Ann Arbor in the liquid fuels department. And I'm the one, I asked him about methanol being blended in gasoline, and he said they're working on it, or looking at it. And 30 percent would be the upper goal.

So that's basically all I can tell you, as far as I know about how that would affect the fuel stream.

MR. ALI: Sy Ali with Clean Energy Consulting.

You use quite a bit of SOFC. Do you have any experience at all with SOFC? Practical experience? Or just the assumptions?

DR. MOORE: I'll defer to Tony for that question.

MR. LEO: Yes. I mentioned that we're developing SOFC for power generation with support from

DOE fossil energy.

We're also looking at SOFC as an electrolysis platform with support from EERE, as well as reversible for energy storage. So we've demonstrated very, very high hydrogen production densities and very, very high efficiencies. And as Jared indicated, you can get such high efficiencies that unless you dump heat into the system, you're literally more than 100 percent electrical efficiency, but you have to make up that difference in heat. So that's where the application of the waste heat. So we've shown all that.

MS. GELLICI: Other questions?

MS. JENKINS: I wanted to say thank you, Dr. Moore, for your presentation. It sounds extremely interesting.

I'm trying to visualize some of the products that you can produce. Say this technology, you get the funding you need, can you list off some of the products? It sounds like we've got a new form of energy that can do a whole lot of, provide a whole lot of different services to humanity and maybe goods. Can you just sort of name off some of the products, or in the future what we could use this technology for, outside of having an emissions-free vehicle?

MS. GELLICI: Could you identify yourself please?

MS. JENKINS: Oh I'm sorry. I'm Bev Jenkins with e-Commerce Consultation International.

DR. MOORE: The syngas economy, there are many industrial processes that use syngas, and so that would give them an advantage.

There's several processes that also use oxygen, pure oxygen.

For instance, there's a new novel steel-making process that uses pure oxygen and hydrogen. So if we were looking to bring back steel, that would be a way to increase efficiency quite dramatically.

I mean, there's a lot of processes out there that use pure oxygen. And I can't name any off the top of my head, but of course also everybody in this room knows that CO2 could have a lot of different commodities as well. So I know the pipeline system is going to be very bold and big, and it's a big ask. But, you know, so is the electricity system, and we, we don't make decisions based on cost/benefit analysis that are major.

Granger Morgan, the department head of Engineering Public Policy, when he goes to theory, a policy analysis class, the first class, he challenge the students, have you ever, have we ever made a huge decision as a country with a cost/benefit analysis? And no student can come up with the answer to that question. So we didn't do that with electricity.

So you know, this is a vision. And I guess I should just say that. Thanks for the question.

MS. GELLICI: Anyone else at this point?

Wonderful. Please join me in thanking Jared.

And maybe one more thing, if you could just, what's the name of the journal that the article's appearing in?

DR. MOORE: International Journal of Hydrogen Energy.

MS. GELLICI: Great. Thank you again. Thanks.

To all of our panelists, I'd like to offer up another round of applause and thank our group of folks here today.

I'd invite all of the gentlemen on stage to take a seat in the audience. We're going to move into council business for a few minutes here.

As we're getting resettled, I did want to take a moment to thank Hiranthie Stanford who is our Director of Meetings. Please joint me in acknowledging her. Thank you so much.

As many of you know, this meeting was supposed to take place in March, last month, and we, despite having the mildest winter I know of on record, the one day we have any snow was the day we were supposed to have the meeting. So we got to do everything twice. So it was a challenge, and Hiranthie, thank you. You did an exceptional job. Thank you.

We did have a record number of attendees register for this, so thank you all for attending. We do operate with just two full-time staff, so we're pretty busy when it comes to hosting our biennial meetings. So again, we appreciate your being here for round two.

The final portion of our program this morning will focus briefly on a few business reports. I'd like to begin by introducing NCC's Finance Committee Chair and our NCC Vice-Chair, Greg Workman. Greg will provide us with an update on NCC's financial status. Greg?

MR. WORKMAN: Thank you, Janet.

As always, I'd like to acknowledge and thank the many members of the National Coal Council Finance Committee. The committee's membership has increased greatly during the past year, and we appreciate the contributions, time and effort from all the committee members. There's a list of members in your packets. Thank you, Finance Committee members for your help in managing the NCC's finances.

I'd particularly like to thank Dan Roling, who will be assuming the role of NCC Finance Chair immediately following this meeting. It's been my pleasure to have served as NCC Finance Chair for a number of years now, and it's with equal pleasure that I relinquish this role to Dan. So thank you, Dan.

In each of my reports for the past few years I've noted that we've been on a three-year mission to right our financial ship in the midst of turbulent seas and raging storms. I'm pleased to report today that following five years of negative year-end income balances, we finished the year of 2016 in the black.

(Applause.)

MR. WORKMAN: Hooray.

Based on our current budget, we are also projecting a positive return for 2017. Our success has been based on reducing expenses, closely monitoring our costs, as well as increasing our membership.

Membership now stands at over 140 members, and an increasing number are now paying members of National Coal Council.

Financial vigilance must continue, of course. As a reminder, the NCC does not receive any federal funding or financial support from the Department of Energy. Our operations are funded solely by membership dues and sponsorship support.

I'd also point out that our dues are voluntary, and that some of our members elect not to pay their dues or are unable to do so. In the past, more than 20 percent of our members have not paid dues. We expect that to be about 18 percent this year. So the number of non-paying members is decreasing, but not significantly. This obviously poses additional burdens on our finances that we need to take into consideration every year.

We continue to struggle with achieving our meeting sponsorship support goals in light of industry challenges, so please consider supporting NCC with a meeting sponsorship for the fall, fall event of 2017 in Birmingham.

In your packets, you will find an acknowledgment of those NCC members who have contributed financially to the council this year, along with a list of in-kind supporters. On behalf of the NCC leadership, I'd like to thank those of you who have paid your dues, sponsored this spring NCC meeting, and provided in-kind support.

I'd especially like to acknowledge members of the Chair's Leadership Council who provide additional financial and leadership support to the NC. I'm going to specifically name Tom Alley with EPRI; Kipp Coddington, University of Wyoming; Mike Durham with Soap Creek Energy; Sheila Glesmann with ADA Carbon Solutions; Danny Gray with Charah; Dennis James, North American Coal; John Kennedy with Dynegy; Deck Slone with Arch Coal; Mike Sorenson, Tri-State; Scott Teel, Southern Company; Kemal Williamson, Peabody. So thank you one and all.

As always I would be happy to address questions about NCC's financial status following today's meeting. Please feel free to contact me by phone or email. Janet has my contact information. She also has Dan's contact information as well.

So Janet, that concludes my finance report.

MS. GELLICI: Thank you, Greg. I appreciate your many years of service as Finance Chair. We greatly appreciate it.

I'd now like to invite Deck Slone to provide us with an update on NCC's Coal Policy Committee activity. Deck is serving as Chair of NCC's Coal Policy Committee. Deck?

MR. SLONE: Thank you, Janet. Good morning, everyone.

Since we published the CO2 Building Blocks Study back in August we've been spending a lot of time, the council's been spending a lot of time in committee on determining where we go next. And so what's the most constructive direction, what sort of work flow should we be envisioning, what sort of topics and issues.

So we started a process where Janet sent out a note to, I think to the entire membership soliciting ideas, thoughts from the entire membership back in the fall. We got some really good input, so thanks to all of you who participated and provided input there.

And then things changed November 8th, obviously. So we had a significant even here nationally on November 8th. And so post-election, as we began to think about how priorities might be changing at DOE based on kind of what we thought we knew about where this new administration would be going, we reached out to a broad swath of the membership, about 40 to 45 folks, and asked the same questions. In light of this new filter, how do we think about the direction for work going forward?

And again, it was a good representation of folks and got good input there.

The Carbon Subcommittee met in January and wrestled with this, had a good, robust discussion on this front. The Leadership Council has discussed it. The Executive Committee has discussed it twice. So we've really been wrestling with this idea of where do we go next, and what would be most constructive?

We had a great dialogue.

I guess we would, the input that we've received we translate into sort of two basic themes. The first one might seem self-evident. I'm not sure that it really is.

But the first point is that we need to play a more active role in supporting DOE's objectives. And again, maybe that's clear that what we should be doing, but getting that alignment is really important. And the world has changed, and we do have a new administration so we need to be mindful of that and we're starting that process of engaging very closely as witness this meeting.

Then we decided that we had five really, five priorities that we would focus on and these are broad subject areas. Energy security and independence; economic and job growth; infrastructure development; balance of trade and exports; and regulatory reform.

I think you can hear even in those areas this idea that things are evolving and we're trying to be more responsive to what we think the new administration, the direction the new administration is taking and where we can be most constructive in helping them and assisting.

The Leadership Council met this morning with a group of Department of Energy and National Energy Technology Laboratory leadership, some of them still here. So thanks to all of you for a great discussion. And we started this process of trying to figure out okay, where do we take that? Where do we take those topics?

I think there was good alignment, there was good exchange there. So we're going to be working on sort of what we learned today and the coming back to them, and as we continue to see DOE sort of build out the team and Secretary Perry lay out his vision, we'll continue to refine some of these ideas.

I would lay out for you five specific priorities that we've identified we think can bear some fruit. We're looking at the following.

And first is initiatives to preserve and rejuvenate the existing coal fleet. That really is coming to the fore again and again as sort of probably the single most important priority for the committee.

And that really is an issue of, look, we've seen a great rationalization of the fleets from 2011 when we had 315 gigawatts. We could, by the end of this decade, have 80 gigawatts less of coal fired capacity, so we really need to make sure that the existing fleet is still doing what it does well, which is provide tremendous value to the country in all sorts of ways. So that would be a top priority.

But additionally, looking at initiatives to advance new markets for coal. Initiatives to jump-start first of a kind advanced coal plants and technologies. Initiatives to advance export markets for coal and provide support for export infrastructure, and initiatives to support America's industrial and manufacturing sector in a whole range of ways.

And so again, those are the areas that we're looking at and we're going to continue to wrestle with. We're going to be reaching back out to the group without a question. But figuring out how we do that. Is it through white papers that we can provide to DOE? Is it additional direct exchange and interaction? But all this work is ongoing.

Again, I appreciate everybody's input and we'll look forward to a continuing discussion on these fronts.

MS. GELLICI: Thank you, Deck. Appreciate your leadership of the Coal Policy Committee and appreciate your report today.

I'd now like to invite Lisa Bradley, Chair of the NCC Communications Committee to provide us with a brief report on NCC Communications Committee Activities. Lisa?

DR. BRADLEY: Thank you, Janet.

What the Communications Committee does is help to roll out the reports. So we have the report in September, and we had help with developing fact sheets for the report, for getting that out into social media and the print media. And I think we were very successful with that effort this year.

But that came out in August, and there were other things going on so we didn't get as much interest and web hits as we normally would get with our other report.

But that was very successful, and Janet, we have to thank Janet and her team of people who helped us to write the fact sheets.

Janet also does the newsletters. We have the web site, which has been updated in the last couple of years and is a great resource for information that we have.

And we're on social media, LinkedIn, Facebook, and Twitter accounts, and that's where we're talking. The Communications Committee meeting was very well attended. We had a very lively discussion about what our objectives are for communications, who are our audience, et cetera, and how can we use social media more effectively?

So we decided to move ahead. We would develop a communications plan, and we have a subcommittee that is going to work on that plan and then bring it back to the full communications committee.

So some of you have talked to me about being on that plan. If all of you could email Janet so we just know, I have everyone's title information and we'll have a conference call soon. And hopefully at the next meeting we can report back to you with our progress.

MS. GELLICI: Thank you very much, Lisa. Appreciate it.

We had about 40 folks at the committee meeting yesterday, so it was great attendance and great participation.

We have just a couple of governance issues to quickly take care of before we adjourn.

First we have a few proposed changes to the NCC's Articles of Incorporation and Bylaws.

Yesterday the NCC Executive Committee approved the following changes to the NCC's Articles of Incorporation.

First, we are revising the caption to reflect that the articles are amended and restated in April of 2017, and removed the reference to the Virginia Code in the introduction, because of a change in statute there.

And then the second, more I think substantive change proposed, was the removal of the prohibition on the use of proxy voting. These proposed changes were sent to all NCC members of record at least ten days ago.

The issue on the proxy, I would mention, you know, as we are producing more white papers and reports for the Secretary on a more regular basis, people can attend meetings or web casts. So we'd like to provide you with an opportunity to actually be able to record your vote in this way if you're not able to participate.

I would like to entertain a motion from the floor to approve the noted changes to the articles. May I have a first please?

Dan Roling I have in as a first. Second? Ram Narula. Thank you.

Any discussion or questions?

(No response.)

MS. GELLICI: All in favor?

(Chorus of ayes.)

MS. GELLICI: Are there any opposed?

(No response.)

MS. GELLICI: Is anyone abstaining from voting?

(No response.)

MS. GELLICI: I see total approvement. Thank you very much.

Again, two substantive changes are proposed for the NCC's Bylaws. Article 1, again, removing the prohibition on use of proxy voting. And adding the ability of members to appoint the Chair of the NCC and the NCC Executive Committee to vote with their proxy according to written instructions.

And then the second change that we're

proposing is to revise the maximum number of members that can serve on the NCC Executive Committee, so we would be raising that number from 30 to 20. Not that we would fill that out necessarily, but we have a significant amount of interest from our members in serving in leadership capacity. And so we'd like to be able to accommodate that. I don't want to keep coming back to you every meeting, asking for a one, one, one increase.

So additional formatting changes were made as well, and they're noted in the summary of the Bylaws that were sent out the members and are in your member packet.

I would like tp entertain a motion right now to approve the noted changes. If I can get a first please?

I have Marty Irwin in the back. Thank you.

Second? Deck Slone. Thank you very much.

Any discussion or questions at this point?

All in favor?

(Chorus of ayes.)

MS. GELLICI: Any opposed?

(No response.)

MS. GELLICI: Anyone abstaining?

(No response.)

MS. GELLICI: Seeing none, the motion passes. Thank you very much.

Our final business item to address is the election of a Chair for the National Coal Council. The NCC Executive Committee has put forth Greg Workman, Director of Fuels with Dominion Energy to serve as Chair of the National Coal Council.

Thank you for stepping up.

I would like to entertain a motion at this point to approve the appointment of Greg Workman as Chair of the NCC.

May I have a motion, please?

Jackie Bird. Thank you.

And a second?

Bob Bibb. Thank you very much.

Any discussion? Questions?

(No response.)

MS. GELLICI: All in favor?

(Chorus of ayes.)

MS. GELLICI: Anyone opposed?

(No response.)

MS. GELLICI: Anyone abstaining?

(No response.)

MS. GELLICI: Thank you. Motion passes.

Greg, thank you very much again, for

agreeing to serve and we look forward to working with you.

Now in compliance with FACA requirements for this meeting, I'd like to note that this meeting is duly authorized and publicized and is open to the public. The public can submit comments to the Department of Energy, or if any individual wishes to speak, they may do so at this meeting.

Those who wish to speak may do so at this time.

Does any member of the public wish to speak at this time?

(No response.)

MS. GELLICI: All right.

I'd like to thank our meeting sponsors, most especially Soap Creek Energy, who is our event sponsor. Also thank you to Tri-State Generation and Transmission, Occidental Petroleum, Charah, ADAES, Dominion Energy, Ferreira Construction, Headwaters, and Savage Companies for your sponsorship support of this meeting.

As Greg mentioned, these meetings would not be possible without that additional financial support. So thank you very much for that.

A shout-out to a few people. I want to

thank Jeff Miller who is handling our videography; Dave Scholnick, who is handling some of our AV needs.

I also wanted to thank the folks that put the program together today. David Denton, Ellen Ewart, Jerry Oliver and Connie Senior.

And then finally I'd like to thank four ladies in waiting, as I call them. There are four women who are awaiting official appointment as it were by the Secretary, but last December just jumped right in.

And each one of them took one of the studies that we've done, the last four studies that we've done for the Secretary, and summarized those. They took the very substantive reports and kind of boiled them down into six pages or so.

And then they organized all the findings and recommendations by energy security, economic job growth, infrastructure, the five points that Deck mentioned. And so they spent a good portion of their time and effort in December doing that, and those materials we'll be using in our conversations with DOE.

So I'd like to thank Katherine Dombrowski, Susan Jackson, Kim Johnson, and Connie Senior. Would you please join me in thanking those folks.

(Applause.)

MS. GELLICI: The next meeting of the National Coal Council will be held on September 26th and 27th in Birmingham, Alabama. We're grateful to Scott Teel and the folks at Southern Company for agreeing to host us on an optional tour of the National Carbon Capture Center, so we'll be having our meeting at the Ross Bridge Resort in Birmingham, and then doing a tour of the NCCC.

At this point is there any other business to bring before the council?

Seeing none, I thank you all again for attending, and especially for the great attendance on the repeat.

So sorry again for any inconvenience we might have caused, but thank you again for being here.

We stand adjourned. Thank you for attending, and safe travels home. Thank you. Cheers.

(Whereupon, at 12:06 p.m., the meeting in the above-entitled matter adjourned.)

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REPORTER'S CERTIFICATE

DOCKET NO.: N/A

CASE TITLE: Meeting of the National Coal Council

HEARING DATE: April 19, 2017

LOCATION: Alexandria, Virginia

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 U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy.

Date: April 19, 2017

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