Rep Keith Ammon (00:00:02):

All right. I call the commission to study nuclear technology with a much longer actual title than that to order. It is 1:42PM. And do a sound check on the Zoom participants. Give me a thumbs up if you can hear me okay. I see thumbs up.

(00:00:25):

Alright. I put a link to the agenda in the chat, so we'll start with that. And you should all have a print out in front of you. We have an agenda item to approve the minutes from our November 21 meeting. Does anyone have any edits to those minutes? And if you haven't read it, I'll give you a few minutes.

(00:01:17):

We do have a quorum. Looks like there's eight of us in the room and one on Zoom. I'll accept a motion to approve the minutes. Catherine. Seconded. (Bart Fromuth) Seconded. All in favor? Aye. Any opposed? Minutes are accepted.

(00:01:41):

There's a public sign in sheet. And everyone is sitting way far away from me. <laughs>, so as the sign in sheet comes around, please at least fill out your email and your name and that'll help us keep you in the loop on this meeting and future meetings.

(00:02:03):

Alright, so we, we'll start with some public input. I know people might [unintelligible] meeting. If you have, if you're on Zoom, you can use a hand raising feature if you'd to just give us some public input. Maybe you've been following our meetings to date and you have some suggestions or criticism for our commission. Feel free to raise your on Zoom. Anybody in the room? Would you like to comment, or... OK, all quiet? Anybody on Zoom? And we'll have another chance to do this at the end of the agenda.

(00:02:46):

All. So that'll keep our meeting shorter. Alright. So first item up we have a presenter, our local maven, expert on how the utility grid works, Meredith Angwin. And we'll ask her to come up to the desk. Maybe, maybe could Marc could you move over one (sure) and Meredith can sit on the camera?

Meredith Angwin (00:03:18):

That's great. Thank you.

Rep Keith Ammon (00:03:19):

Yeah. So Meredith has written a book, Shorting the Grid. And she makes a very complex subject accessible to the average person. I served two years on the Science, Tech, and Energy Committee, House committee, and I learned probably more from a couple hours of reading your book than the two years on that committee. A very complicated subject. and Meredith, you're also a nuclear proponent? Yes. And so you'll give us a little bit of an overview of how the grid works, kinda bring up the speed on some of the complexities and then talk a little bit about nuclear. Is that the plan?

Meredith Angwin (00:04:01):

That's the plan. Thank you very much.

Rep Keith Ammon (00:04:02):

Alright, so I'll pull up your slide deck here and I'll gonna share my screen and then I'm gonna pass this over to you. Oh,

Meredith Angwin (00:04:25):

You do a sound check sometimes?

Rep Keith Ammon (00:04:29):

Yeah, we'll do a sound check your up, your slides and then I need to share them with the group here. Okay. So we're gonna just do a sound check. Meredith, could you just say, testing 1, 2, 3.

Meredith Angwin (00:05:03):

Testing 1, 2, 3.

Rep Keith Ammon (00:05:05):

How, how is the sound on the zoom? Someone give a, we got a thumbs up. You can see my screen. Thumbs up. Alright, we're good to go.

Meredith Angwin (00:05:13):

Okay. I, I think we're the last slide.

Rep Keith Ammon (00:05:16):

Oh, we are.

Meredith Angwin (00:05:17):

Yeah. So we have to go the first slide because otherwise it gets even more confusing than it needs to be there. Okay. So here is the, the name of the dissertation and the next slide is just a little bit about myself. I have a masters degree in physical chemistry. I worked on corrosion and pollution control problems in many areas of the utility industry. geothermal underground equipment and nitrogen oxide control, nuclear. And and I ended up in nuclear. Then I was working all this time in, in California in semi-retirement. I came out to the East Coast and I became active in the consumer liaison group of ISO New England. And when I was trying to explain, I said New England to people and how things happened I realized that I needed to write a book. And so I did.

(00:06:23):

And that's the book. Next, the next slide. The is I feel that the first thing I have to say about the book about what my presentation in general is that, you know, the subtitle in the book is the hidden Fragility of our Electric Grid. And I begin saying things like that. And I wanna be sure people know what I think the goal is, okay, not just, you know, it's fragile, or we need to invest more, we need this. Okay? The goal, the goal is a strong grid, and the three factors are a strong grid. And the first factor is reliable electricity. If you don't have reliable electricity, you're gonna find that you don't have a strong grid. You don't have a reliable grid. People will be leaving in the, the area and or as one of my friends said, what's good for Generac isn't good for the country.

(00:07:27):

So moving along now for the, the electricity also has to be relatively inexpensive, so it can be used for health and happiness and manufacturing. We're seeing in Europe now Germany's electricity prices are soaring, and Volkswagen and others have said, well, we don't know if we'll be able to stay in Europe. And then electricity should be made with low levels of pollution and ecosystem disruption. So those are the important things, and I'll be talking mostly about reliability. So if we go on to the next graph, this is my outline, and I'll just read it because I feel it. You have the policy grid and the physical grid. People sometimes talk about things as if sheet of paper will change, the wiring. It won't. Okay. What is an RTO? We're an RTO area that is a regional transmission organization area. Most people have no idea how this differs from other areas and how the auctions work.

(00:08:37):

I'll talk about types of situations that are winners and losers. And the RTO auctions, the fatal trifecta for grid, the importance of baseload power and nuclear energy. So let's go start physical grid and the policy grid. The physical grid, if we move to the next one, is, oh, oh, I got them both on one side. That's great. Convenient. The physical grid grid is transmission distribution, substations, linemen the dispatchers and the control center and so forth. It is mostly limited by laws of physics, not by regulations. The policy grid on the other hand, is all about choices of policy. Net zero, net metering, no coal plants, no new nuclear plants, whatever. And to be blunt, the policy grid can also be described as mostly about how the, the physical grid is paid for. I mean, that is what, how the policy is actually implemented.

(00:09:50):

So in the next slide, I wanna say that the, the two grids are often confused. I was very trying to keep Vermont Yankee online and I was very active with that. And Vermont Yankees had contracts with Vermont Utilities, executive 212 and Vermont Yankee continued operations selling into the RTO auctions until 2014. In 2013, anti-nuclear people said, we don't even need that crime. We're not using it right now. Well, no, Vermont Yankee didn't disappear just because the contracts disappeared. Vermont Yankee was using Vermont Yankee Power. Vermont was using Vermont Yankee Power in 2013. Changing the contract does not change the wires. And everybody, every now and again, I have to point that out as the next slide shows the next situation, which is I, there's, I, as I've been talking about the book, I realize there's kind of a third grid, which is the could grid.

(00:10:59):

It's the grid you usually hear about, you know, we could use just wind and solar. We could build a lot more transmission to the west where there's a lot of sunshine. We could, okay, research I did my whole life on research. And research does not turn into deployment very quickly. So I feel that one of the problems I have is I'm trying to explain to grid we have, and people are very eager to ask me about the latest and greatest possibility of the "could" grid. So onwards. Okay, now let's talk about RTOs, regional transmission organizations. Okay, we're in an RTO area. Not all the country is. A lot of the country is. This next slide, there are two major types of grid governance. There are traditional vertically integrated utilities. And the utility is responsible for reliability. It owns the power plants or partly owns the power plants and distribution systems.

(00:12:03):

It receives a rate of return. And in general, the, the two big regulators are the State Public Utilities Commission. And for bigger issues, Federal Energy Regulatory Commission. FERC, the federal, the RTO areas, which are sometimes called deregulated, although they have bigger and thicker books of regulation than the vertically integrated do, is that if you, if you are a, if you're a generating facility, you're basically a merchant generator, you supply power. Distribution utilities buy that power at auctions run by the RTOs. And regulation is multi-leveled and easily gamed. For example, if you say to the RTO, you're not building enough, we're not building enough something, the RTO said will answer you, well, I'm sorry, but in the, the resource advocacy and what gets built is not our problem. It's a state problem. And if you go to the state, the state may say, well, we can tell them to build it, but if, if they're not gonna make money on the auction, they probably won't.

(00:13:18):

So it's really an arch - anyway, moving ahead. It's a, it's a complex and, and, and easily gamed system. So if we go onto the, the next thing I need to talk about how the auctions work. Now, unfortunately, to really talk about this, I need the whole book. So I'm just gonna talk about the energy auctions right now. The energy auctions run every five minutes, and they're what's called economic dispatch. The controller knows from yesterday's projections how much electricity the grid will need in the next five minutes. And he starts, but obviously he's got a lot of computers helping him, but he starts with the lowest price for the next kilowatt hour. Okay, the next kilowatt hour, what's the lowest price? Whatever's giving him that price, he buys as much as they can give. So let's go into a simple example. The plant A gives bids $20 per megawatt hour, plant B bids in a $30 per megawatt hour.

(00:14:27):

Plant C bids in at $40 per megawatt hour. They're all needed. So the RTO will say to everybody, all right, plant C, $40 per megawatt hour set the clearing price. You all get the $40 per hour. Okay, so moving on to the next slide. We have to look at incentives. I mean, I think it was Charlie Munger, but he was hardly the first to say, "show me the incentives and I'll show you the results." And so, what do the power plants owners want? They want high clearing prices. The reliability of grid is not their department, okay? They want the high clearing prices, and the clearing prices get high when the grid is teetering on the edge of not being reliable, and even old and expensive plants are being run, they'll set that high price. And so part of the rolling blackout, the rolling blackouts in California in 2001, we partially cause Enron did game the market.

(00:15:33):

You can see how it can be done, take a couple of plants off, some higher price plants are forced on. The plants you still have on are getting that high clearing price, everybody's happy. Well, with some exceptions like the customers. Okay, so the next the next one, this is another problem. And winter storm early costs people in Texas to lose power for 45 minutes. 45 hours. It caused, it caused about 200 deaths. The clearing price went up to $9,000 90 cents per kilowatt hour, $9,000 per megawatt hour. And the designer of the system said the market was quoted about three days later to say the market had worked as designed. In other words, sorry about that. But that's how it was supposed to work. Clearly it didn't work. Okay. I mean, it worked as design with trying. Next, next one. So what, let's look at what kind of plants have advantages in an auction system? Well, this is the, the most important slide about this. And this was done by Entergy, and then it was redone. It was redone by, by Nuclear Energy International. Okay? The left hand side is nuclear, and the right hand side is wind. And in the middle you can see natural gas or oil gas turbine. So nuclear plant is notice that its mostly it's mostly something's going wrong. Did I turn it off? Off?

(00:17:36):

Okay, we're back. I hope I didn't, no, I just think it, okay. Well, I I won't touch it. <laugh>. Okay. So you see that the nuclear side there is mostly that brown color and the wind side is brown and green and so forth. The nuclear plant makes about 90% of its money by selling kilowatt hours. That's the energy payments. The, the blue sections are what's called capacity payments. And they are for being on the grid and available. Now, the nuclear plant is not only on the grid and available, but it's making a bunch of kilowatt hours while other plants are, are getting more and more of their payments from capacity. If you go over to the wind side, you'll see that it's got a lot of capacity payments, a very small amount per kilowatt hour. And then the the green is the fact that it gets out of what's called out of market payments.

(00:18:46):

It gets production tax credits, and it can also sell something a imaginary, it is a kilowatt hour, it's a REC, renewable energy certificate. So, for example a utility in, in Massachusetts may ha be required to buy by the laws of required to buy 30% of its power from renewables, but there aren't that many renewables around in Massachusetts. So it comes to someplace like Maine and buys RECs, and that qual that qualifies it. So if you're a winter when you're making these RECs and you, so that's a major part of your income. Okay? So so in, in, in my opinion, there are so how does this all affect the grid as a grid? In my opinion, there's a failed trifecta for a grid. And you've see, I've seen it work out many times. And of course then people called me after and said, because of your book and your description of what happened on our grid, on the new northeastern grid, at one point I kinda, I kinda understood what was going on in Texas.

(00:20:01):

I said, yeah, that's right. Okay, the fatal trifecta for grid, let me explain it. And I have the t-shirt to prove it because somebody decided to make a t-shirt. Okay? The fatal trifecta for grid is overreliance on renewables that start and stop on their own schedule, not the demand schedule. Now, I started out in renewables, and when I think about my, my favorite kind of grid, it includes solar. So I was not trying to bash renewables as bash them, but they're on their own schedule. You know, the wind died down in Texas at a really bad time. Now backing up the renewables, we have natural gas, which is delivered just-in-time through pipelines. Why can't we back it up with other things? Well, there are a lot of different systems that can load-follow, but, but you need to back up a renewable, you need something that's fast, fast response and natural gas does that.

(00:21:09):

And then so you say, okay, now the trouble with natural gas is that it's delivered just-in-time. And unlike a nuclear plant, which has over a year's fuel on site, natural gas, it shows up when you're gonna use it. And if it doesn't show up because something, because for example, a lot of natural gas has been diverted to home heating or because there's there's problems on the line. Cause the weather is so bad and the condensers are I'm sorry, the pumps are, are having their problems. People say, well, we'll depend on the neighbors, but no, no, no, the neighbors are having the same weather. Quebec imports power in mid-winter. Okay? It's important to know Quebec is relying on Ontario in mid-winter. We're not gonna get more power from Quebec in mid-winter, that just isn't happening, okay?

(00:22:10):

Overdependence on the neighbors. And the next thing, next slide is that, oh, fuel is key for winter reliability. Fuel stored on site or fuel replenished by delivery. Fuel stored on site includes oil, coal. We could include reactor fuel reactor, water behind the dam for a hydro plant or fuel could be replenished by delivery. If you go on to the next one, I wanna show you that na oh, natural gas is, is, is just in time delivery. And I think we can say that in cold snaps, people's demand on the grid increases, but gas becomes less available. So in the northeast it's been oil to the rescue <laugh> the ISO New England had a winter reliability program, which is basically that they paid gas generators that could burn oil also to have oil onsite. And this is a picture that I wanted to put my book, but I couldn't.

(00:23:17):

So I put in, in all my, my slides, the people who put the book together said, nobody's gonna see those little blue lines. You see the little blue lines are, the green lines are the oil that was used during the winter coast snap that was purchased through ISO New England. The blue lines at the top that are almost invisible are the, are are what the power plants bought on their own. So if you think maybe we only didn't have to do that, well, it did. Okay, we'll go on to the next one. We will see that winter reliability was near failure. And this was a, this is all from an ISO New England winter report, winter retrospective after this all happened and pointed out that all depletion at one stations went all the way down to a one day supply. Okay?

(00:24:16):

So luckily it warmed up. We're always happy when it warms up. Okay, let's go on. I wanna talk about this a little bit because one of the problems with talking about the grid is that people will say, no, we don't need baseload power. We need flexibility. So if you look at the next slide, you'll see this is a typical, it's a couple years old, but the thing is, the is the ISO has gotten to be like light colored on black and, and stuff. It's the same shape. It's just that it shows up better. Okay, so you see, the thing is that over, over on the left, it's the number of megawatts demand on the grid starting at midnight, zero and ending at midnight. And the orange line is what actually was happening, the blue line is ISO's projection, which was pretty darn good, as you can tell.

(00:25:19):

And as you see, the demand on the grid rises, and then we have a little bit of a duck curve as the solar kicks in, and then it rises up again at night as the sun goes away, and then it falls. Now, this is a really important thing that the grid operator has to keep things in balance all the time. Now, one thing is that, I don't know how many of you were geeky little kids like me that read a book called, How to Lie With Statistics? Oh, okay. Nobody reads these things anymore. How can, okay, well, anyway, the reason I wanted to say that is one of the things this points out, and ISO New England is not lying here, it's just doing its thing, but you notice that there's a lot of variation, but the bottom is 10 K, okay? So you don't see baseload on this because it's invisible. This is 10 K that is below the, the fluctuations between 10 K and 15 K.

(00:26:25):

So onto the next slide. (You're talking about how it starts at 10K instead of zero. Below 10K is the baseload.) Right. I wanted to talk about basic now that, that's a simple illustration that somebody could say, well, you should have shown a colder day. You should have shown a different day. I wanna show I do something, Senator [unintelligible], I hope I get that right. he did some slides about New York power based on the New York ISO, and I feel that these are important to show the important baseload. So let's go to the next slide. And this is, this is the electricity demand in New York in megawatts. And it goes from January 1st through December 31st of, of I take 2021. And you notice that although there's all that jagged stuff, it never really goes below 4,000, right? But there's all that jagged stuff. So there is, there is variable demand, but it doesn't go below 4,000.

(00:27:40):

So that number, that 4,000 that is baseload, that is it. So if you, so somebody's gonna say, well, yeah, Meredith, New York City, the city would never sleep, of course. So let's go on to the next one. He did an amazing thing. He went to all the different subsections of New York state, and he looked at what percentage was 24 times 365 demand shown in, in orange. And what is the variable demand shown in yellow? And you notice New York City has a very high variable demand, and yet the orange is still 65% of power. And if you go to upstate you know, Genesee Hudson Valley what there's one there called what is it called? Something like capitol or something like that. Yeah, capitol. They are all 65, 67, 67, 67. One is 54%. But what I'm trying to say is baseload exists, and it doesn't just exist in the city that never sleeps.

(00:28:59):

So if we go on, I just wanna say I'm, believe it or not, I am almost done with this <laugh>, I wanna say a few words about nuclear energy. That's it. Nuclear energy is good for a grid. No, I'm gonna say more. First of all, it is very solidly baseload power. Secondly, it has got over a year of fuel stored on site, right? So you don't have the interruptions with like Texas, lemme tell you, Texas had compressors to move natural gas to the power plants. And then they began having really big problems. And the Texas grid operators decided they had to shed load, they had to turn off parts of the grid. And they did. And one of the things they did is they turned off some of those compressions. So yet other power plants went off. So what I wanna say is a year fuel stored on site is nothing to, to say, oh, yeah, that doesn't matter.

(00:30:08):

It matters, okay? It really matters. You can't turn off a year fuel stored on site by a mistake. And then it also has traditional support for grid operations. And this, I dunno, I'm gonna have to write another book about this. The thing is that rotating electric machinery behaves differently on the grid than inverter based systems and the wind turbines and the solar inverter based systems. So just take my word for it, talk to an electrical engineer. But basically nuclear has traditional support for grid operations, including something called inertia, which keeps the grid going through minor glitches. Okay? And so, oh yeah, I've already said this. And let me, I, that's this. I think this is gonna be the last slide. Yeah, maybe not. What's the next slide? Oh, other advantages, of course, it has a small footprint, a small plant that takes up a couple of tens of acres can provide power for a huge area of weather resistant, not weather dependent and low environmental impact, including very low co2.

(00:31:39):

So these are tremendous advantages to nuclear energy. And I wanna say that a conventional statements are often about how you're supposed to behave. And I, I try to behave well, I really do. You wouldn't believe, but it's true. And I try to behave well. So, you know but, but when you get right down to it, don't eat meat. Don't keep your house too warm, don't travel don't use the lawnmower unless it's a push lawnmower, don't use plastic straws. It's all up to me, that is not the way to run it. I mean, a citizen is a citizen, not a lone actor. A citizen acts as a citizen and understands the death toll if anything happens to the grid and supports a reliable grid, which in my opinion, includes nuclear. It's about choices, not sacrifices. There can be sacrifices, sometimes there have to be sacrifices, but I just find that this whole business of guilting people, instead of making choices for reliable grid kind of upsets me. So it's up to all of us as citizens. And I wanna thank you. I wanna say that I'm always happy to hear you and I'm pretty easy to reach as long as you've got my name, because I've got, Meredith Angwin dot com as my website, Meredith Angwin at Gmail is my email address, at Meredith Angwin on Twitter, and so forth. So also, I really like that electricitymap.org website, so I always put a little plug for it. So thank you very much.

Rep Keith Ammon (00:33:23):

Excellent. I think it, your lights across the room, that was a great presentation. Let's open it up to any questions. So feel free to ask.

Chris McLarnon (00:33:36):

Could you say a little bit more about the inverter based issues as we go to more renewables people are talking about storage.

Meredith Angwin (00:33:44):

Yeah. Yes. The question is, can I talk more about inverter based issues? And the answer is it's pretty hard to do that because they're having ISO New England is now having workshops and, and, and task force on how to deal with all the inverters on the grid. Let me lemme say this. The two areas I think that it really comes down to are inertia, which means can the grid ride out a small glitch, and also something called bars reactive power, which is invisible but is important. And so I always want to be a electrical engineer when I get a question like that. But I will say that right now, for example, they're trying to figure out how to make virtual inertia on an inverter based grid. And the fact they're even doing that is something that you should think about. Cause inertia, what is, what allows you to ride out the small problem? There's a task force on virtual inertia.

Chris McLarnon (00:35:12):

So it's about inertia, it's not about frequency?

Meredith Angwin (00:35:17):

Now in all honesty, the frequency, as far as I know, the frequency can be fine tuned on an inverter. And so frequency is, inverters can do frequency. They don't have the, I dunno how to describe it, the heft to keep it all going though.

(00:35:44):

They don't have the heft to keep it all going. So I, people will, will tell me that, oh no, it's great having inverters on, cuz you find could fine tune and this and that's true to some extent, and if you couldn't fine tune the inverter, you couldn't add a wind turbine to the grid because, you know, when you're beginning to add it, it may or may not be on the same frequency as the grid. I mean, so they're good for fine tuning, but they're not good for bulk support. And I, at this point, I feel like I'm getting way beyond my electrical engineering abilities. I feel that the, the problems on the grid are mostly based in policy and indeed putting more inverters on than you, than you and, and losing your inertia, that, that is a policy that isn't something about a grid naturally, you know, and so forth. Yes.

Rep Keith Ammon (00:36:53):

Could you just talk for 30 seconds about frequency response and how important that is and what could go wrong if it's not managed?

Meredith Angwin (00:37:00):

Well, yeah. Well, the thing is, what the grid operator is doing is he's keeping the keeping the demand and the supply in balance. But it's a practical matter. What he's doing is he's keeping the frequency between very tight boundaries, because when the demand goes up and the frequency begins going down, unless you add some more supply. And so you keep that between these very, very tight boundaries. And what happened in Texas they, they got to the base of the boundary and they had to begin, they couldn't add more supply, so they had to drop load, they had to just turn people off the grid, because otherwise, if the frequency really goes way down, the rotating machinery may be harmed and it will take a long time to bring the grid back up, possibly weeks. And so you really want to shed load before you get to that. So they are watching that frequency all the time.

Rep Keith Ammon (00:38:15):

So that could lead to rolling blackouts, brownouts?

Meredith Angwin (00:38:18):

Yeah, that's not, well that's the thing is that what the Texas operators did is they decided to shed load and to turn off the parts of the parts of the grid. And then the idea was that they would turn those parts on an hour later, and then they would the turn off a different part. Unfortunately, that's why they, that's why it's called rolling. That is you're off for an hour, but then you're on, the darkness rolls onto another section of the grid. Unfortunately, when things get too bad, you can't roll it. And that's what happened in Texas. They couldn't roll it. And so parts of the grid were off for like 45 hours and approximately 200 people died. So there's a, there's a question.

Rep Keith Ammon (00:39:06):

Yeah. We have a question here on zoom representative Spier, would you,

Rep Carry Spier (00:39:12):

Hi.

Rep Keith Ammon (00:39:13):

There you go.

Rep Carry Spier (00:39:14):

I believe that nuclear energy is probably, I've always thought it was a pretty good idea and the technology's getting better and better, but I'm wondering if you can make a comment as we will inevitably move to more and more nuclear energy. What are we gonna be doing with all of the nuclear waste? And I know there's technology moving to go to implementations that generate less waste, but right now we're still generating and you have to store it on site forever. And so I was wondering if you make some comments about how the technology for handling that is moving as opposed to just storing it in the ground forever.

Meredith Angwin (00:39:53):

Well, for one thing, there are there are nuclear plants that can convert it directly, that you can just reuse it. And, and I believe the Oklo plant is one of those, and it's certainly true that some of the CANDU plants will do it and so forth. But in terms of the waste of people talk about the waste a lot and are concerned about the waste a lot. I'm a chemist and in all honesty, there's a lot of dangerous stuff in the world. My undergraduate honors spoke project was a project that evolved carbon monoxide, flourine gas, and liquid hydrogen. I mean, that's what it was. And what I'm trying to say is, so when I hear about something that's basically a ceramic that's not going anywhere, it's not a gas that can get out, it's, it, you know, it, it's, it's not getting anywhere.

(00:40:50):

I just like, okay, it is a problem. I but it, it's not the worst problem. Also, you realize that nuclear waste is a very small amount of waste. I mean, people say, oh, there's millions of pounds. Okay, let me, lemme me compare two power plants. Vermont Yankee. And and the Bow plant, which you're all familiar with, the Bow plant went, were operating full-time, used 40, 100 ton cars, hopper cars of coal every day. Vermont Yankee when it refuels, the fuel is delivered in a semi and then it is used for the next 18 months. It's a very small amount of material. And so when you talk about how much waste you're going get, you know, you're going to get a lot more with that coal. And I'm gonna tell you coal ash is not a benign substance, necessarily.

(00:41:56):

So all that, all the waste is it, you know, all the waste from a major power plant can be stored on an area about the size of a convenience store, parking lot, all the, with the waste. It's not a, it's not a large amount of stuff. It's not stuff that escapes into the environment easily. And so but again, people, it, it is dangerous. I mean, I wouldn't say it's not dangerous because, I mean, I've been around a lot of stuff that's dangerous and we don't go around and saying, oh, it's not dangerous. That's a way to get dead. But you know, it, it is controllable in a way that a lot of other waste streams aren't as easily controllable. I dunno if that's a differnt answer, but you could also look at the CANDU reactors up in Canada and they can just, they can just use it as fuel.

Rep Carry Spier (00:43:02):

Thank you.

Rep Keith Ammon (00:43:09):

Okay, any other questions? Anybody in the room? Good to go? Did you learn a little bit about how the grid works and so it's very interesting how complex that system is. Alright, so thank you Meredith. That was a great presentation. Thank you for driving all the way from Vermont today. Snowy weather.

Meredith Angwin (00:43:30):

Yeah, it stopped snowing. If it was still snowing, I don't know what I would have done.

Rep Keith Ammon (00:43:34):

I don't know if you can hear me on Zoom, you can see my hand off to the left there. Thumbs up if you can hear me. Okay, great.

(00:43:34):

So we'll move on to our second presenter today and that is Jackie Siebens from Oklo and Oklo is a small modular reactor company with unique offering. And Jackie, I'm gonna pull up your slides. The version of Zoom I have, if I make you the host, it'll turn off the recording. So I'm gonna be your, your slide manager and you just say, next slide when you're ready and I'll try to follow.

Jackie Siebens (00:44:25):

That works.

Rep Keith Ammon (00:44:26):

I'm gonna download it from our handy website. Alright, I'm gonna share my screen. I'll put my mic on mute and Jackie, you're off mute.

Jackie Siebens (00:45:13):

Okay. And everyone can hear me okay. Just let me know if I can't, everybody got really small when you shared screen, so someone speaking to the mic, if you can't hear me otherwise, I'll just assume that you all can. So first I just wanna say I thoroughly enjoyed hearing Meredith from you as someone who has read your book and find it unbelievably valuable to my own career. I actually was just, our, our policy fellow is, is online watching this as well and I, I sent him a message and said, I'm buying this book for our whole team. This was a really great, great idea for things to buy for our team for Christmas. So I'm really excited to be here with you all today. I will likely be building on or emphasizing some of the key points that Meredith made in her presentation as it relates to what we are doing at Oklo.

(00:46:15):

And so really excited to talk to you specifically about our company the advanced vision reactors that we are working to deploy. And actually the second half of this presentation is gonna dive pretty deeply into the final question from that last round from the representative about what about the waste. Cuz we are actually pursuing a recycling program to recycle not only the spent nuclear fuel in our, from our existing plants that are operating today like the Seabrook plant in New Hampshire, but also our own fuel as well moving forward. There's a number of reasons why we're doing that and I'll, I'll dive into that a bit as we, as we sort of move on. And so I don't know if we can make the presentation full screen or if it's weird because of the PDF version that I sent it in.

(00:47:06):

But I think we can probably make do with it as is if, if we need to. I'm not sure if folks are gonna be able to see really well some of the text, but not a problem. So a little bit about me before we get started. Just so you know who I am. I am the director of External Affairs and Policy for Oklo. We are a company that's based out in Santa Clara, California. I am actually based in Washington, dc the reality is, is that in today's day and age, half of our employees are sort of scattered all across the United States. And we are working to deploy advanced vision powerhouses. And I'll dive into the technology a bit as we get started here. So we can go ahead and jump into that first or that next slide.

(00:47:47):

So as I mentioned, so we are a startup company that was actually started back around, well, really around 2011, 2011 to 2013. And we are developing small advanced reactor systems. So as Meredith was talking about the incredible value of our existing fleet that operates across the country today and provides over 50% of our, our carbon-free power. When you think about the existing fleet, including Seabrook, these plants while having a small footprint compared to large solar and wind installations and things of that, that liking, the site for Seabrook is approximately 900 acres in total for the, for the site. So small relatively speaking. But what we are actually looking to deploy at Oklo and I'll get into this a little bit more in comparison, the entire site footprint for one of our reactors is about the size of a single family home.

(00:48:49):

So substantially smaller with inherently and simple robust safety systems. And I'll get into what we mean by inherently safe here momentarily. Because our, our reactors are so small, it gives us great flexibility when it comes to siding and where we can operate our reactors. And we also require minimal water resources compared to our existing fleets that also goes and lend to that flexibility factor. And we were the first advanced reactor company to ever have a non-light water reactor design for a commercial reactor accepted for a license application to the Nuclear Regulatory Commission. And I'll get into some of the history of, of that and where things stand with our licensing application. Now moving forward, go on to the next slide please. So this is a rendering of our Aurora, our Aurora powerhouse, our first reactor design that we worked with a company called Gensler to put together.

(00:49:47):

Cause we really wanna to fundamentally illustrate how different conceptually our reactors will look compared to the existing fleet. When you think of the existing reactor fleet, most often you probably envision the two cooling towers, one or two or however many there are that that emerge from the landscape because our sites are sites and our plants are so much smaller and our business model and sort of our mission is to actually be able to deploy these at scale in communities to power anything from remote communities to industrial facilities and things of that like universities, hospitals we wanted to make sure that we could conceive of a design that would be welcome in and sort of be able to integrate into the, the communities that we hope to deploy in next slide.

(00:50:37):

So how does it work? it's very simple actually at the root of it all. so heat will ultimately be generated just like in almost any other electricity generation station. You can think of whether that heat's being generated by coal or by natural gas. ours is used using nuclear metallic fuel. and then that heat is then transferred by liquid metal coolant to a power conversion system. And the after heat removal is accomplished by a natural airflow around the system which is fundamentally different than what, what's currently used in our existing fleet of reactors. But in short, we're putting specific metals together in different configurations to make heat ultimately, which is what almost all of our, as I said, are our power generation facilities do at the end of the day. And go to the next slide.

(00:51:28):

And this is something that's been proven before. So we are certainly doing a lot of innovative things with our design, but one of the reasons that we are really set up for success, especially when it comes to working with the Nuclear Regulatory Commission, is that our design is based off of something that operated for 30 years at Idaho National Laboratory, and that's what is referred to as the experimental breeder reactor II (EBR-II). This was a sodium cooled fast reactor, just like our design that operated from 1964 to 1994 at the lab in Idaho. And it demonstrated the inherent safety characteristics that we talk about and the ability to recycle fuel. Next slide.

(00:52:07):

So what is also different about our reactor from the lightwater reactor designs that operate today is that we use fast neutrons. And what fast neutrons do ultimately is enable us to unlock a lot more of the energy that lives in that uranium than the existing reactors are able to do. And they also allow fast reactors to recycle our own used fuel and the spent nuclear fuel that is currently being stored from the reactors that operate today. Next slide. So our design is very simple, as I mentioned. It's a very small compact fast reactor unit. It's metal fueled with liquid sodium metal coolant. That's what cools the reactor. it's inherently and intrinsically safe. The cooling is actually, basically gravity helps us move air through the system such that it cools automatically. Very streamlined design. And as I mentioned, our plans for our company are to develop a full fuel cycle supply chain such that we can recycle both spent nuclear fuel that's that exists today as well as our own fuel that we use in our reactor. Next slide.

(00:53:16):

So the cost and operating benefits of this are immense. Our plant requires 1000 times fewer parts than one of the existing plants that operate today. So you can kind of just conceive pretty basically of just how much that reduces the cost of construction and day-to-day operations. And the fact that we're a non pressurized also means cheaper and simpler components as well. We also plan to use a modular system for construction of our plants because they are so small. These will be constructed offsite, manufactured offsite, and then delivered to a site and and put in place. Most of the plants, all of the plants that have actually been built in the United States are unique to the site that they were located at. There's never sort of been this modular pursuit before in the nuclear industry, but it will drastically reduce costs as we deploy at scale. And then ultimately our ability to site flexibly and build close to where the power is used will also help reduce costs. Next slide.

(00:54:20):

The other thing that's very attractive about our reactors and we've found a ton of interest in our for our customers is in the fact that we can not only produce electricity but we can also produce process heat. and this is very valuable when we start to think about how we're going to decarbonize the industrial sector, which includes anything from the production of aluminum and cement and glass to things like meat processing plants and Jim Beam distilleries. So many companies have come out and made very aggressive commitments to decarbonization on their own and are now actively seeking solutions that will allow them to actually achieve those goals. And small reactors like ours have become very attractive to, to a lot of these companies that are pursuing these goals in the next 30 years. Next slide.

(00:55:07):

So a common theme that weaves through everything we're doing at Oklo is flexibility. Our ultimate mission is to build reactors that people want and that means all different kinds of people living in all different types of communities. And the size of our reactors allows for a very small geographic and environmental footprint. You can site an Oklo reactor on an acre or less, as I mentioned earlier, a single family home. I usually compare this to, to the footprint of my home just outside of Washington DC And this opens up all kinds of possibilities for siding that will be impossible for a traditional large light water reactor facility. And then again, add to this, the fact that our plants don't require access to water and it opens up even more opportunities. Next slide.

(00:55:49):

So Oklo plans to serve as an independent power producer offering end users the option to subscribe to fission-as-a-service. This model reduces deployment hurdles by allowing end users to sign power purchase agreements and avoid the capital regulatory and operational burdens of owning and operating plants. This is a game changer. This is the first time a nuclear company has pursued this business model. every other nuclear plant that operates in the country has pursued the traditional model where you have a reactor designer who then sells the plant to a utility who then pays to construct it and operate it. The reason that that's been the case is because constructing a traditional large lightwater facility is hugely expensive. Not just the construction cost itself, but you also have to navigate the very, very complex regulatory space in order to bring that plant online and operate it as well.

(00:56:43):

So what we are doing as a company is not only simplifying the reactor design itself, we're removing all of that, or taking ownership, I should say, of all of those sort of burdens that have kept carbon-free nuclear power from becoming accessible to individual companies or communities that choose it. So this business model fission-as-a-service really is a game changer. And I was thinking about it as Meredith was speaking earlier sort of about the complexities of the RTO universe. This really is sort of a different pathway, should communities or companies that are looking to decarbonize be interested in signing a power purchase agreement to draw power from an Oklo facility. Next slide.

(00:57:27):

So when you look at the entire Oklo model, we are ultimately aiming for both flexibility and simplification by owning and operating our facilities and offering PPAs. We really are making advanced fission a real option and all of the different applications that I mentioned before as well across the board, really open up as we sort of pursue this transition to net zero. Next slide.

(00:57:55):

The theme of flexibility and simplification carries through to our licensing approach as well. So Oklo pioneered an application structure for the NRC that ultimately builds from the regulations and stems back to an application structure that is more streamlined and that focuses on what drives the safety case. In March of 2020, Oklo submitted our combined license application that was less than a thousand pages to the regulator. Now if you're thinking about March of 2020, it's probably the worst possible time that we could have ever submitted a license application to the NRC who had never really used Zoom before.

(00:58:31):

Because we, we, I think we submitted our license application and announced it the day before Washington DC completely shut down and declared the Covid 19 a pandemic. So it really kind of threw everybody for a loop, took a long time for us to kind of get our ducks in the row as well as the NR cm, what it looks like to do a license application review via Zoom. But we did, we worked with them and ultimately we sort of came to a crossroads where there was additional information that was required. So we're actually looking to resubmit. We were under review for about 22 months. Didn't lose any of that time. We're gonna be resubmitting in the new year. But ultimately we are still on track to receive approval to build and operate our first Aurora plant in Idaho in 2025 and bringing that online in 2026.

(00:59:20):

So very excited about our timeline for first deployment. The processing for licensing a simple and advanced design like Aurora is new for both Oklo and the NRC. So we're essentially using existing licensing frameworks but carving out new pathways within those, precidential pathways that we hope to utilize again and again and again as we deploy at scale over the coming years. Now, as challenging as it can be to work with a regulator who's been licensing and you know, sort of regulating large scale lightwater reactors for decades, the long pole in the tent for us for deployment is actually not licensing, it's access to fuel. Our plants require high-assay, low-enriched uranium or HALEU, and currently the United States does not have a domestic market for this fuel. Now Oklo has an agreement in place with Idaho National Lab to use processed fuel from that EBR-II test reactor I mentioned earlier.

(01:00:23):

And this is gonna be able to provide us enough fuel to power our first two cores. But beyond that, there's still a pretty big question mark hovering over the entire industry about what the supply chain of fuel for advanced reactors is gonna look like over the next 10 to 20 years. There's some really exciting stuff happening at the federal level. There's a program at Department of Energy that's been authorized and funded to essentially have the federal government partner with industry to ensure that we have domestic fuel supply moving forward for these reactors. But still a lot of work needs to be done in that area and that is one of the many reasons why Oklo is pursuing... Next slide, please.

(01:01:01):

...recycling. So honestly for us it comes down to cost and economics. At the end of the day, there's a lot of reasons to recycle fuel, but as a business, when we, and I'll get into some of these studies here in just a minute, but when we looked at the actual cost benefit of recycling our spent nuclear fuel to make HALEU versus enriching for fresh HALEU, the cost difference was enormous and it really is to me the best case for driving down the cost of a per megawatt hour for nuclear to what once was termed as potentially too cheap to meter. So next slide, we'll dive into this a bit more.

(01:01:47):

So this gets to answering I think some of the ques that last question that was put forth to Meredith's presentation. The US has produced about 85,000 tons of used nuclear fuel since the 1950s and continues to produce about 2,000 tons each year. And this fuel still contains more than 90% of its original energy content. Oklo plans to use electro-refining to separate uranium and the transuranic elements from the shorter lived waste and then fabricate this material into metal fuel for fast reactors.

Now something that I think is important to note here, and we can go to the next slide as I kind of walk, walk this through.

(01:02:24):

This is just gonna sort of illustrate the composition of the fuel and how it changes as you've utilized it in a lightwater reactor, removed it as spent nuclear fuel and then recycle it to use it again. Now at the end of the day, I think it's important to note that recycling spent nuclear fuel isn't a silver bullet for eliminating any fission products that are ever gonna have to be ultimately disposed of. There's always still going to be a small amount of fission products that have to be put somewhere for ultimate disposal. However, recycling the fuel drastically reduces the amount and also the radioactive life of that material. So not completely eliminating it, but compared to what we're dealing with today, drastically reduces as I said, the the actual amount and the radioactive life of that material. So this is sort of the breakdown of that for recycling spent nuclear fuel from our existing reactors, turning it into HALEU and then using it in our reactor today. And then the next slide,

(01:03:24):

once again sort of breaks this down, but this is what the sort of breakdown and sort of the material changes look like when you're recycling spent nuclear fuel from an Oklo reactor. So this is fuel that's already been used in our reactor, taken out, reprocessed, recycled and and then used again. So you still end up with that vision product that has to be ultimately disposed of, but again, very different from from sort of the waste stream that we're seeing today. Next slide.

(01:03:52):

Now there's enough energy in used fuel to power the US for over 150 years. That's a lot. So as I mentioned, the economics is a pretty big case for us, but when we look at the real value that's left in the spent nuclear field that's sitting in canisters today, there's just a lot of value there that we wanna explore and make sure that we're using. Now this is particularly relevant as we're watching current events unfold in Ukraine and the impacts being felt around the world, particularly in Eastern Europe, that are really struggling to figure out how they're going to really gain energy independence. And this is really becoming not only a priority in the near term sort of as an emergency, but really as plans develop for what is it like for Europe to become energy independent in the long run? And American energy independence has traditionally been framed as increasing our production of fossil fuels, but as countries around the world are considering the consequences of more severe sanctions on Russian energy and of course many are also pursuing decarbonization at the same time pursuing sort of a very reliable supply chain for nuclear that includes recycling becomes very attractive. And so we're seeing conversations about recycling, especially at the federal policy level. Gosh really just grow in a positive way like I've never seen before in my career. And that's on both sides of the aisle. The interest in in pursuing fuel cycling has really grown.

(01:05:16):

So as a history or recycling has a history of being very big and very expensive. France is a very good example of a country that has a closed fuel cycle that that recycles spent nuclear fuel from its existing reactors to them to utilize again in those same reactors. That system is large and very expensive, but the combination of fast reactors like ours with electro refining can truly generate a paradigm shift. And key to this is the fact that fast reactors are able to accept a messier fuel. Fast reactors use fast neutrons like I mentioned before, and can access access the remaining energy content. In other words, we can fission the entire actinide vector or nearly all of the relevant material in used fuel. This means that the transuranic waste and spent nuclear fuel can be kept together for the recycling process.

(01:06:12):

And that means we require a simpler process overall because there is no need to separate out specific components like plutonium. And this also has significant non-proliferation benefits. So the existing large scale recycling operation that you see in a country like France has to separate out those specific components like plutonium in order for that fuel to be utilized in a lightwater reactor. Fast reactors don't need that. We can have that messier fuel product, we don't have to separate out the plutonium. So it reduces the cost and complexity of the process and also helps with proliferation resistance because you're not separating out the plutonium. Next slide.

(01:06:54):

The simplification of the process also significantly reduces cost and Argonne National Lab and Landmark Foundation study presented different economic models for both a 100 metric ton pilot facility of ours and a 400 metric ton commercial facility. And the study found that Oklo recycling can produce fuel vastly more cheaply than fresh enriched HALEU. And this is comparing to we did a we looked up what today's market rate would be approximately for high-assay, low-enriched uranium, and that's around just over probably $11,000 per kilogram. So when you look at how this breaks down, with a 100 metric per year intake facility, pilot facility, we could produce approximately two to three Oklo cores per year. And we could produce that fuel for about five to $10,000 per kilogram. So you're already looking at lower than the market rate today, but if we charge for recycling, we could significantly drop that down to 500 to $800 per kilogram.

(01:07:58):

And when I say charge for recycling, there is a lot of interest from companies that currently hold the spent nuclear fuel. So whether that's a utility that is currently storing that spent nuclear fuel on their site, whether it's a company like Holtec who purchases sites and decommissions them and has the fuel, they're very interested in having a company like Oklo take that spent nuclear fuel off their site and then using it. So there is a model that we are pursuing where we would actually be able to charge a company like that to take that spent nuclear fuel, and that's what gives us that extreme reduction down to 500-$800 per kilogram. And then if we scale up to that 400 metric ton per year facility, that gives us six to 10 Oklo cores per year. And if we charge for recycling, it actually drops our fuel costs to negative. And because our company, our business model is power purchase agreements and fission-as-a-service, ultimately that significantly impacts the cost to customers, the cost of the power purchase agreement to customers. So that's what really has driven Oklo's interest in pursuing the construction of a recycling facility. Next slide.

(01:09:09):

So this is just a second piece where we're looking at recycling economics for recycling our own fuel. So after we've run it through one of our Oklo Auroras and then recycling it once again we wouldn't be charging. So it's not quite as cheap, but it's still vastly cheaper than that existing fuel. A really important point I want to make here, and this gets back to a point that Meredith made about how the fuel is key to reliability in an energy system. Oklo Auroras don't need to be refueled for up to 20 years. So that means once we put our reactor in any location, we don't have to do anything to the fuel for 20 years. If there's no fuel stored on site, that then has to be reloaded into the reactor and recycled out. That's it. So when it comes to fuel reliability, really there's nothing else on the market that beats this. She's absolutely right about our existing plants being unbelievably reliable because they can have that, that fuel stored on site and it usually only has to be refueled every year and a half or so for our existing plants. But the fact that we have something that doesn't even have to be refueled for 20 years is extremely attractive to folks businesses or communities that wanna make sure they have an always on reliable source that's available to them. Next slide.

(01:10:29):

And so because of the work that we're doing, we've actually been awarded four different awards in partnership with Department of Energy and the Advanced Research Project Agency for Energy, at ARPA-E. And I'll briefly go through these and, and then I'll close out with our timeline. So the different projects we're working on are all incredibly important actually for our license application, for our recycling facility because what the regulator always wants is existing data that they can rely on as they review that application. So the first was through something called the Technology Commercialization Fund, and this is helping us develop advanced sensors for key different pieces of the recycling process to help with efficiency improvements. The second one is with a program called Open at ARPA-E and this is utilizing machine learning and digital twinning again for recycling efficiency, but also for improvements to, for material accountability.

(01:11:23):

So when you have agencies like the International Atomic Energy Agency and others, and if we ever look to deploy these you know, internationally, which I don't think we will but ultimately this allows us to track where every single piece of that material is at any given moment, how much it is and the composition of that material. So that helps for things like safeguards, it also helps for efficiency so that we know in real time that the product that we're gonna get on the other end of this process is exactly what we wanted. The onwards program is very exciting cuz it's allowing us to demonstrate the recycling process end to end. And this is going to help us develop this technical basis for our licensing application to the nrc. And then finally, we just announced our latest award in partnership with Argonne with the CURIE program and this is specifically helping us to demonstrate the conversion of used oxide fuel from existing nuclear reactors into the metal fuel that we'll be using as for our Aurora reactors and other advanced reactors could use as well like ours. So very exciting.

(01:12:29):

And then last slide is on our timeline for this as well. So we already began pre-application activities with the regulator in 2020. We're looking to submit our license application in 2025 and begin construction of our pilot recycling facility by 2027, 2028 with hopes to bring that online before the end of the decade and then ultimately scale that site up to a larger version. But our plans as a company as you, as I've hopefully laid out for you and I'm happy to a answer questions are very unique in the u in the in the nuclear industry, both in the United States and abroad.

(01:13:08):

We are, as I mentioned very small units. Our first reactor design scales from 1.5 megawatts electric up to 15 megawatts electric in output. And very, very small simple design, flexible siting. Our business model is incredibly innovative and different. We're planning to enter into power purchase agreements with our customers, whether that's a community or a company or government. And moving forward, full steam ahead with the regulator on both our first reactor deployment as well as our recycling facility and ultimately plan to own the majority of our supply chain, especially when it comes to our reactors and our fuel. So excited to have shared this with you all today and welcome any questions. and again, thank you to Meredith for a wonderful presentation and setting me up honestly to talk a lot about a lot of the stuff that, that I wanted to specifically about Oklo and how that kind of ties into the broader grid discussion that you had had earlier. So with that, I'll, I'll stop and answer any questions.

Rep Keith Ammon (01:14:17):

Alright, perfect. Thank you for that presentation. And so we'll open this up to questions.

Richard Steeves (01:14:37):

I have a question. I'm Richard Steeves. I put it on the chat, but

Rep Keith Ammon (01:14:45):

Just hold one second Richard, please. And we'll come back to you. Catherine is sitting off, see, might see my cursor and everything to the, to your right on the screen.

Catherine Beahm (01:15:05):

Jackie, can you hear me?

Jackie Siebens (01:15:07):

I can, yes.

Catherine Beahm (01:15:09):

So I just was curious about your power purchase agreements and then the whole RTO system. Does that mean you have agreements with an industry or community directly and you wouldn't be part of an RTO system and how does that play into the reliability of the entire grid?

Jackie Siebens (01:15:28):

Yeah, so it depends on to, to Meredith's point, we, you know, legally in certain markets right now you, if you wanna be sort of a previous to us wind or solar farm, that's gonna enter into power purchase agreements as an independent power producer previously you still had to sell a certain percentage of your power too, or in some areas you have to sell a certain percentage still into a marketplace or into or to a specific utility. But that's not true everywhere. So we're actually as a company right now and my policy fellow who's on on the line is doing a lot of this work looking into where for early deployment, as we deploy our first units, it makes the most sense for us business wise to, to deploy our first reactors. But yes, the, as a power purchase model I'll just make up an example.

(01:16:22):

Say you have a tech company that is looking to decarbonize their data centers and they want to enter into a power purchase agreement with a generator that can provide the majority of the power, if not all of it, for a data center. That's sort of what our model, that is what our model is set up to do, such that that company could enter into a power purchase agreement directly with Oklo. And it doesn't really impact the overall grid reliability because we are generating power specifically for that, for that installation. This can also be true for military bases. Many of our, our, well, all of our branches of military are looking to decarbonize. And so there's potential applications for Oklo Auroras to help with that as well. So in that instance, again, you would sort of have an island where you'd have an Oklo reactor powering a specific location.

Rep Keith Ammon (01:17:18):

Alright, any follow up? Okay, thank you Richard, I'll unmute you and you can go next. Richard Steeves, you have to unmute yourself. Richard Steeves,

Richard Steeves (01:17:33):

Thank you. Thank you. I'm here. Do you hear me?

Rep Keith Ammon (01:17:36):

Mm-hmm. <affirmative>

Richard Steeves (01:17:37):

Okay. My question is, does thorium mixed with uranium, of course, have a future in your Aurora system?

Jackie Siebens (01:17:46):

No, we are 100% pursuing the high-assay, low-enriched uranium, no, without thorium.

Richard Steeves (01:17:54):

Any particular reason?

Jackie Siebens (01:17:59):

I'm not the expert on thorium but I know that our co-founders thorium was never really on their radar as, as something that looked promising in the near term.

Richard Steeves (01:18:11):

Okay, thank you.

Jackie Siebens (01:18:14):

Mm-hmm. <affirmative>

Rep Keith Ammon (01:18:14):

Thanks, Richard. And I'm gonna go to Representative Spier next. Could you unmute? Representative Spier. Hold, hold down your space bar where you're talking.

Rep Carry Spier (01:18:31):

Sorry. Sorry about that. my, my question is, so you're going through this, which by the way, this is the first time and I've been to a number of these or participated in a number of these, these nuclear descriptions, and this is the first time I've heard a really intelligent recycling program, and I really appreciate that because just being better than coal isn't really good enough because that doesn't, is your process or are you even considering the idea of recycling the fuel and then possibly selling it to those reactors like Seabrook? Is that even a plot applicable? Is that even something you can do?

Jackie Siebens (01:19:12):

No, not so not with the system that we're pursuing. So it's, we're really specifically focused on electro refining and fast reactors, that combination because that's what really shrinks down the size of the facility that's required. It simplifies that process. The interesting thing is though and if you're interested in it, I'd love to, I, I'm happy to share some some things with you on this, but you know, we as a country have looked at the potential of, of sort of a traditional recycling, reprocessing policy in the past that would have looked similar to France's, where we are recycling fuel to be put back into our spent nuclear fuel or into our existing reactors. And the economic case just never stood the test to do that. Now, I think that what we're hopefully gonna see is, is over the next 20 to 30 years, 10 to 30 years, we're gonna see a massive increase in the deployment of these more advanced designs like ours.

(01:20:10):

And now not all of them are small like ours. So we're starting out right with this 1.5 to 15 megawatt scale for our first design. We have plans as a company to scale up over time, never to something as large as sort of one of our traditional operating plants today, maybe up to like 50 megawatts or so. But Terra Power is another advanced reactor company that's planning to deploy their Natrium reactor, which is larger and is also a fast reactor and could utilize the fuel that we're talking about recycling. So I think for us starting out, we're certainly looking to recycle the fuel to be used in our own reactors, but like our long-term plan is hopefully to see fast reactors other, other than ours deployed at scale such that we could actually sell this to other companies that would use it.

Rep Carry Spier (01:21:00):

How would I get the information you're talking about? You said you had information that you could share about this?

Jackie Siebens (01:21:05):

Yeah, if you just wanna learn more about the history of sort of recycling policy, we're processing policy here in the us more related to the spent nuclear fuel for existing fleet. I'm happy to just follow up with I can follow up with Keith or whoever and, and get that over to you. But our we have somebody on our team that's done a lot of work on that, and that's a really helpful timeline that he's built out. And I can send you some links to stuff, so I'll make sure to follow up.

Rep Carry Spier (01:21:35):

I just put my email in the chat.

Jackie Siebens (01:21:38):

I don't have it in front of me right now but I I will follow up and make sure I get that to you.

Rep Carry Spier (01:21:45):

Thank you.

Rep Keith Ammon (01:21:46):

If you could include me in your communications, I'll make sure that the full commission gets to see that. All right,

Jackie Siebens (01:21:53):

Thank you very much. Great.

Rep Keith Ammon (01:21:56):

And then we had one more from Rep Stapleton. You are unmuted.

Rep Walter Stapleton (01:22:01):

Yes. Thank you for taking my question. I'm wondering if the experimental breeder reactor in Idaho that you mentioned is operational, is that your first prototype? Or are there other reactors in the world of similar design that are operational at this point?

Jackie Siebens (01:22:21):

Thanks. So the EBR-II reactor stopped operations back in 1994 after operating for about 30 years. And so our first fuel, actually our first two cores are going to be made from the spent nuclear fuel from that test reactor. So right now Idaho National Lab is in the middle of processing that fuel such that we can use it in our first plant that we're building at that, at the lab actually. So no, it is not currently operating. But there are other fast reactors that are operating today. Unfortunately China is actually pretty far ahead of the US when it comes to the actual construction and deployment of first of a kind advanced reactors. Russia has also operated a number of these over the years as well. So this is certainly not a new concept.

(01:23:19):

Another interesting thing about just the history of, of nuclear power in the United States. in the early days before we really built out or pursued as an industry and as a country one type of design, there was really exciting work being done on test reactors that included things like ours with the EBR-II reactor, but even other test reactors before them. Were looking at that, that were building out a lot of the different designs you see being pursued today that are termed advanced reactors. Now, there's a lot of things that have advanced since those first first test reactors were pursued decades ago, but ultimately there were a series of events that led to the sort of traditional pressurized large lightwater design being the design that, that the country pursued to build out at scale. And so now we just kind of find ourselves in this, in this moment where what's old is kind of new again and in a great way. And and that's where we find ourselves seeing not only our reactor as a fast reactor as well as the Terra Power reactor but also you have X-energy who's pursuing TRISO fuel. These are all things that have been conceived of before, but that are now finding that moment where we really need to see the increase in deployment of nuclear for reliability for to address, you know, pollution and all of these different things.

Rep Walter Stapleton (01:24:48):

So we're basically in a catch up mode to try to catch up to China. How about in Europe? Where are they at with this sort of technology?

Jackie Siebens (01:24:59):

Well, they're certainly interested in it. So I was actually, I just attended as part of the industry delegation to the IAEA's Nuclear Power Ministerial Conference they held in Washington, DC back in October. And as part of that delegation, we met with the majority of European countries, especially countries from Eastern Europe that are really struggling to find that path forward for energy independence. But especially for things like district heat that are so crucial in the winter. and so they, there's not, as the US I would say certainly leads if you look at Europe on the design and sort of private sector innovation towards deployment of advanced reactors. There's some projects underway in the UK. But ultimately if you look at sort of the countries and ha the countries, the companies that are pursuing advanced reactor designs the customer interest domestically here in the United States, the progress with the regulator here in the United States, we're leaps and bounds ahead. I would say.

Chris McLarnon (01:26:06):

Thank you.

Rep Keith Ammon (01:26:07):

All right. Thank you Representative Stapleton. Any further questions? I would to bring Matt Levander to the fore. My question is, there's a lot of spent fuel sitting at Seabrook and, you know, not knowing enough about the technical details of that. I'm wondering if what Oak talking about is a good fit for you know, recycling some of that fuel at Seabrook. And Matt, maybe you have some details on that.

Matt Levander (01:26:46):

Sure. So first off, thanks, thanks Jackie for a great presentation. It certainly was very insightful for me. Just to kind of give a background of Seabrook, typically the reactor refuels every 18 months. During that time, one third of the core is removed and replaced. It gets removed and sent to the spent fuel pool where it cools for about four years. After that time, it gets transferred to the ISFSI (Independent Spent Fuel Storage Installation) facility at our site. [An ISFSI] is a concrete pad with a concrete enclosure on top of it. The concrete enclosure houses modules which hold the fuel, which is then passively air cooled. And that's where it sits. So all the fuel that's been removed from operation dating all the way back to the early 90's takes up, you know, a very, very small, you know, less than the size of a football field and it's sized to store all the fuel until 2050, which is when Seabrook's license currently expires. I do think there is certainly a potential that, that maybe what Oklo is looking at could potentially benefit Seabrook in the future. I do know that there's a lot of regulatory and political hurdles between, between now and then, but I do think that there's the potential that it could be a good solution in the future.

Rep Keith Ammon (01:28:11):

Alright. Alright. So we're just time check here. We're 20 minutes after 3. We lost a few minutes on some technical stuff.

Chris McLarnon (01:28:22):

I have a question.

Rep Keith Ammon (01:28:23):

Just on second. Could someone pass this over to Chris?

Chris McLarnon (01:28:37):

Hi Jackie, this is Chris McLarnon. The question about this recycling, when you pull the efficient products up, do they go back to the original fuel supplier? Who takes ownership of that material?

Jackie Siebens (01:28:48):

Mm-hmm. <affirmative> Yeah, so that's one of the fun questions. It's my job to look into <laugh>. So right now I'm working really closely with our Director of Fuel Affairs. So the way this works now as part of the Nuclear Waste Policy Act is that ultimately the Federal Government Department of Energy is responsible, right, for the ultimate disposal of the final waste form. The question is, if you have a transfer of that material from a utility to a company like Oklo, does that contract with federal government also transfer? Does the contract that you have with Department of Energy for Ultimate Disposal still live on? So the answer to your question is, I don't know. and that's what makes it so fun working at the frontier of this sort of new next gen nuclear stuff. But I will say that we are very hopeful that that is the case. but to get to Matt's sort of point about not just regulatory questions, but like some of these bigger federal government like contractual questions about what this has never been done. So what does it look like process-wise to run the bases on all of that? This, and that's what we're working on right now. yeah.

Chris McLarnon (01:30:02):

Okay. And just one other, a separate question. The system that you're talking about, the Aurora, is it load following?

Jackie Siebens (01:30:08):

Yes it is. So one of the interesting things about our power purchase agreements is we know that not in every instance are we going to necessarily have a customer that requires all the power that we're producing all the time. So we're gonna have some pretty exciting customer announcements in the year ahead. but I'll, I'll say some of the customer interest and agreements that we've already signed are, we're sort of designing these in such a way that we have one or two or three sometimes PPA customers that sort of allow us to make sure that the power that we're putting out is being utilized. And if it's not by one customer, we can be sort of flexible in using it for others. But yes, ultimately we are designed to be load following.

Chris McLarnon (01:30:52):

Okay, thank you.

Rep Keith Ammon (01:31:09):

Maybe it, it's not a good time to go into this, but those large scale, fast response, variable load customers are very interesting. I think there's a few categories that they fit into and it's sort of some, you're not wasting energy, we from NuScale last meeting that they actually vent their steam. And so there's a way maybe to capture that energy, you know, if you, if you have a load that's variable.

(01:31:42):

Alright I don't see any more hands in the room. Lot of people look, they're paying attention and they're really excited about this topic and it's really exciting. You know, it's, you're on the forefront of brand new industry that's super exciting and we're trying to learn as much about it as we can. So thank you, Jackie, for your presentation and we really appreciate it and we'll be back in touch with soon and you're welcome to, to stay on meeting. We have maybe five or 10 minutes left, just some housekeeping.

(01:32:19):

Pulic input. I think we've kinda had opportunities for that as we went through. So unless any hands on Zoom. Alright.

(01:32:28):

And I thought we do a little member discussion just about like the overall plan for the rest of our commission meetings. I think once a month is probably great. That means we have maybe 11 more meetings going into December next year. And so we started with Nuclear Energy Institute, so that gives more per perspective on the industry and NuScale which is a reactor manufacturer. We had Meredith's presentation that gave us another perspective of how the grid works. And then Oklo, another manufacturer We have a few manufacturers lined up and so I'm thinking, you know, interspersing manufacturers with other industry experts. But we have Terra power, some of these were mentioned earlier, X-energy lined up, Westinghouse lined up, BWX technologies lined up. Some that I'm interested in pursuing is LightBridge which is a fuel processor manufacturer. Because we heard a lot about how fuel is part of the equation. The office of Nuclear Energy we haven't heard from. But we also have our consumer advocate for the energy grid, Dom Kries, we could invite to come and participate in the meeting. I don't know if he'll want to present.

(01:33:52):

The Department of Energy. Maybe we wanna have someone from the department present. I'm just throwing ideas out there. Shoot any of them down or, you know, come up with your own, introduce your own. But how would we like to proceed for the rest of the meetings? I think we need some skeptical voices telling us why this all will take longer, it costs more than you we're hearing. We'll probably want to hear folks with those voices too. So any thoughts on that?

Karen Testerman (01:34:26):

You might want to touch base with Tom Popik here. He does investigations into resilient societies. His whole objective is making use resilient.

Rep Keith Ammon (01:34:48):

So you send me his information and I'll vet that person. How do you spell his name? Tom.

Karen Testerman (01:34:54):

P-o-p-i-k.

Rep Keith Ammon (01:34:55):

P o p i k. Anybody from the commission? Would you like to, Catherine?

Catherine Beahm (01:35:03):

What about the Nuclear Regulatory Commission? I've heard a lot about the length of time, get permanent regulations, that's thing. And this is cutting edge, I guess I'm kind curious as to what kind of legislative hindrances, regulatory hindrances could be, you know, out there.

Rep Keith Ammon (01:35:21):

Okay, so the NRC and asking about regulatory hinderinces, why do they take so long to do what they do

Catherine Beahm (01:35:29):

Well, more in terms of like what, what are they gearing up for? Are they thinking about

Rep Keith Ammon (01:35:34):

What's their timeline?

Catherine Beahm (01:35:37):

Improve their regulations, incorporate this kinda feature?

Rep Keith Ammon (01:35:42):

That's a good idea. Alright, we'll do that and feel free if you wanna, if you wanna bird dog on that, tracking someone down. But I'm happy to send emails too.

(01:35:53):

So we have our federal delegation and just signed the inflation Reduction Act, which has some nuclear perks in it. And the Biden administration owes our state a little bit of compensation for removing the first in the nation from our state. So maybe there's something there. Iif anybody has a direct channel to our federal delegation, maybe there's some you know, some avenue there just getting more information about what's going on at federal level. That would be a big help to the Commission.

Catherine Beahm (01:36:28):

I know the EPA has been having a lot of listening sessions about the IRA trying to figure out where they're headed with that, so I can get some names.

Rep Keith Ammon (01:36:35):

The EPA is having listening sessions and Catherine will get some names for us. So Matt, you're being volunteered to track someone at the NRC.

Matt Levander (01:36:55):

I would be happy to find that contact for us.

Rep Keith Ammon (01:37:00):

Okay. Excellent. All right. Any other suggestions for how we proceed with this meeting? Is that, does that sound like a rough idea that we've can kinda shape as we go?

Bart Fromuth (01:37:12):

Yeah, I mean it hasn't gotten all the attention I think it should, but I'm curious to see what the White House has to say tomorrow about the the latest fusion potential breakthrough where they had a net gain in terms of energy output versus energy input. And if this turns out to have some legs to it, I, since it is a new nuclear technology, I'd be supportive of having someone potentially from the federal government involved in the project come and speak to us about the breakthrough.

Rep Keith Ammon (01:37:41):

Great. So we should keep our eye on what's happening with fusion. That might be a longer term solution, but yeah, it's certainly interesting to bonus. Yeah, right. Okay. I'll work with you on that. Okay. Alright, cool.

(01:37:54):

All right. Anything else? And I just had one thing moving onto the next topic. So I don't know if you noticed, you probably have up website for the commission. I figure we want to get the maximum input from the public. So it's nuclear energy, sorry, nuclearnh.energy is the website. And this is to commission members. Let me share my screen. This meeting will be posted. So here's the announcement for this meeting. We will have a video posted to this page for this meeting. Future meetings will be posted there. And I've been bugging the committee, the commission members about their bios. Okay, so the bios are on the About page and if we go to commission members. And Alex, I need a headshot from you. But so real quick. I had to use a summarization tool to kind of get us all of the same size bios because the page will lay out really funny if I didn't do that.

(01:39:04):

So check your bio, make sure there's nothing inaccurate about it. And you can put different contact links at bottom, your LinkedIn page, your Twitter page, phone number, whatever. It's, so and this is for our guests to know who's on the commission and a little bit about our background. And so we can, you know, we can have good public relations.

(01:39:30):

So I need somebody to be my backup in case I get hit by a bus. I need somebody to give all the passwords to and maybe make an admin on the website. So if you don't raise your hand right now, I might be picking one or two just so that there's redundancy and if something happens to me outside the situation. Alright, any other,

Bart Fromuth (01:39:57):

I volunteer for the backup.

Rep Keith Ammon (01:39:57):

Okay. I trust you. Alright. Any other outstanding over business? Anything that we need to address?

(01:40:08):

Alright, and then setting the date and time for the next meeting. Let's just talk real briefly. We have this facility and it's great. And we also maybe have access to the DBEA, depends on the date, depends on the date. And they have a conference room's a little, it's a little more intimate. It would fit all of us. And they have a thousand dollars web camera that follows you around the room, which is really cool.

Alex Fries (01:40:36):

It's called the owl.

Rep Keith Ammon (01:40:38):

It's a really great setup for Zoom meetings. So that would be my preference, but I don't want, I wanna get input from everyone. Is everybody okay. So the BEA is right across the street from the Statehouse. It's above, if you know where Tandy's Backroom [Tandy's Pub] is, it's a restaurant on the first floor. Does anybody have an objection to that? Cause I want it to be unanimous. I know you're, you're probably the most inconvenienced by it, Cathy.

Catherine Beahm (01:41:21):

Well what I've heard is it's hard to get the public up to the second floor. This is the only room that has those TVs. It's an accessibility issue. It's also personnel issue.

Rep Keith Ammon (01:41:37):

It's a little less secure,

Catherine Beahm (01:41:38):

It's not very high tech.

Rep Keith Ammon (01:41:41):

It's been great. So Alex

Alex Fries (01:41:44):

Happy to look into it next. We'll

David Shulock (01:41:52):

How's the parking?

Rep Keith Ammon (01:41:55):

You can park in Storrs Garage. We won't do it on a session day, obviously. Storrs Garage is right behind it.

(01:42:23):

Alright, so, so, and if you say no, then I'll be back to and me didn't. Exactly. So I'll send out. Thank you. Thank you for coming guys, it's good to see you. I, I'll send out another Doodle, we'll shoot mid-January. Does that sound good everybody. Doodle is a schedule survey. Alright. And I think that's it. I mean we'll work on some action items was the next thing We'll work on some new try to vary our presentations and also filter in existing people that we lined up that are manufacturers. So

Catherine Beahm (01:43:08):

Might be good to back to the statute to figure out what we're trying to get to.

Rep Keith Ammon (01:43:13):

That's a good idea.

Catherine Beahm (01:43:15):

It was fresh in the first meeting.

Rep Keith Ammon (01:43:17):

Yeah. And that's also on the website if you wanna look, but that's true. That's really like a checklist that we have to sort of check off and make sure that we covered it all.

(01:43:31):

Alright, motion to adjorn. Bart's motion. Marc you seconded. Meeting adjourned. Thank you everybody on Zoom and if you singed in with your email address we'll put you on the email list. Thank you.