Rep. Keith Ammon (00:00:15):

Welcome everyone. We're going to get started with our meeting. The time is 9 0 1 and we'll go right into guest presentations. Nathan, I see that you're on, and I'm assuming Eric is with you.

Nathan Raike - ISO-NE (00:00:32):

Eric is currently in the waiting room to get in.

Rep. Keith Ammon (00:00:38):

Okay. Does he have a minute to come back?

Nathan Raike - ISO-NE (00:00:46):

He's in his office. I think he's in the Zoom waiting room.

Rep. Keith Ammon (00:00:50):

Oh, he's in the waiting room. Okay. I've been paying attention to that and I don't see Eric there. The invitation has a Teams link to it, that Outlook automatically added, so check and see if he's in Teams.

(00:01:09):

So Nathan, we're counting on you to get Eric if you could.

Nathan Raike - ISO-NE (00:01:54):

So I'm working with him.

Rep. Keith Ammon (00:01:58):

Everyone in the chat, I'm going to put the agenda that we're going to be following in a link and you're welcome to. So this commission has been very public with all of our information, we have every video online, every transcript of every meeting, all the minutes, presentations from guests. This has been the most transparent commission probably in the history of the State House. So just to set the record straight on that. And so you're welcome to when the time is appropriate. You're welcome to give any kind of comments that you would like and we'll be calling that out on the agenda.

Nathan Raike - ISO-NE (00:02:45):

I see Eric is joining now.

Rep. Keith Ammon (00:02:48):

Yeah, welcome Eric. And just a little precursor here when we get into discussion, there's two microphones in the room and sometimes it interrupts our flow to pass the mic from one to the other, but it makes it difficult to have people on Zoom here and also later when we try to do the transcript. So just be, if you're in the room, just be conscious of where the microphone is so that your words can be heard.

Rep. Michael Harrington (00:03:18):

Can I just impose here just for one second?

Rep. Keith Ammon (00:03:20):

Sure.

Rep. Michael Harrington (00:03:21):

Eric, are you there? Hear me? Can you hear me, Eric?

Eric Johnson, ISO-NE (00:03:26):

Good morning. Yes, yes, I can.

Rep. Michael Harrington (00:03:30):

One second here. Could you pass on congratulations to Mark Cowell and his retirement for me and hope he has a great one. Thank you.

Eric Johnson, ISO-NE (00:03:38):

Will do.

Rep. Keith Ammon (00:03:41):

Alright, Eric, welcome. Thank you for joining us. You may have thoughts prepared, but one thing that I'm interested in hearing from you is a little so I can understand better how the interconnection queue works. I think that might be one aspect of your presentation, but if you have slides to present, I think you should be able to do that now. And if not, just feel free to begin anytime. Great. And for anyone listening, I put a link in the chat so if you go to the chat you can see what we're going to be talking about. Alright, Eric, go ahead.

Eric Johnson, ISO-NE (00:04:29):

Keith, could you just raise your hand? I just want to see who's talking in the room. You guys are at a,

Rep. Keith Ammon (00:04:35):

My hand is off zoom.

Eric Johnson, ISO-NE (00:04:36):

Okay. Oh, you're on the right.

Rep. Keith Ammon (00:04:39):

My computer has to be close to the screen.

Eric Johnson, ISO-NE (00:04:40):

Alright, very good.

Rep. Keith Ammon (00:04:41):

Yeah, so I can't sit in the middle.

Eric Johnson, ISO-NE (00:04:46):

Okay, fair enough. Thank you. So it looks like we're at the top of your program. Can you just give me a time check on how much time you want us to cover? This shouldn't take terribly long, but I don't want to run over

Rep. Keith Ammon (00:05:00):

20 or 30 minutes, whatever your discretion.

Eric Johnson, ISO-NE (00:05:05):

Okay, sounds good. And my colleague Nathan is on as well. If there's any questions that you have along the way, feel free to jump in and if there's any questions that we can't answer today, we'll follow up with you.

Rep. Michael Harrington (00:05:18):

Great. Can I just put one?

Eric Johnson, ISO-NE (00:05:20):

So let me start.

Rep. Michael Harrington (00:05:21):

Eric, just one quick thing. I would encourage you not to assume that people know much about the interconnection queue because I'm guessing most people don't.

Eric Johnson, ISO-NE (00:05:33):

Understood. Okay. We're going to go through it at a pretty basic level, so hopefully that helps. So I'll talk today about ISO is an organization and I think what your group is looking at is relevant to the resource mix that we started with in the beginning of wholesale markets, where we are now and what's on the horizon. We'll talk about the queue process and then there's some publications that might be helpful as well. So starting with our organization, ISO was created in 1997 in the same timeframe when Congress and FERC were opening, opening up the transmission system to competition. So new generating resources could come in and provide power onto the grid, not just the assets that were owned by the vertically integrated utilities, but provided a pathway for merchant generation to come into the system. And at the same time, in the late 1990s, the New England states, with the exception of Vermont, began the process of restructuring the industry on the retail side, giving each customer a choice of their competitive supplier.

(00:06:55):

And in most cases, the utilities were required to divest their generation assets. So we went from a system in New England where almost all of the generation was owned by vertically integrated utility companies. That's still the case in Vermont, but in the rest of the region, most of the generation is privately owned. In merchant hands we're one of the most divested regions of the country we're regulated by FERC. So the formation of the ISO was approved by the commission in 1997. I'll talk through the timeline for the roles and responsibilities that we were given. The primary responsibility we have is for reliability and we operate under reliability standards that are set at multiple levels, but at the highest level by the North American Electric Reliability Corporation or NERC. NERC was given responsibility by FERC to be the Electric reliability Organization following a legislation that was adopted in 2005.

(00:08:07):

So that came on the heels of the blackout 2003. Two things that are unique features of our organization in this restructured marketplace is first of all, we're independent of all the companies that are participants. So as an employee, as employees, Nathan and I do not hold any financial assets related to any of the companies in the marketplace. That applies to our entire staff, our management team. We also have an independent board of directors and the code of conduct applies to them as well. The second aspect of our organization is that we are neutral on technology. So the markets really determine which types of resources are selected. The ISO doesn't plan the system around any particular resources or resource characteristics.

(00:09:05):

If we think about sort of what guides the ISO, we have a mission, which is part of the documents that are approved by FERC. And the mission is something that we bring to our stakeholders and has been vetted through the stakeholder process. So what we do is part of what we would call the ISO New England tariff, and we can't make unilateral changes to our mission. So if we wanted to change that in terms of our day-to-day responsibilities, that would go through a process within NEPOOL, the New England power pool. That's the stakeholder process in the region, and then it would be filed with for FERC approval. The ISO's vision is something that was adopted by our management team and the board of directors about two years ago, and it's more aspirational. So it looks at the evolving resource mix in the region with the advent of more renewable resources and plans for additional clean energy, whether it's within New England or imported from neighboring regions. And the vision is really to use the power of the competitive markets and technologies that continue to evolve, which certainly is relevant to this conversation and make sure that we have a reliable transition to a clean energy future. So just a quick pause on mission and vision. I'll ask if there's any questions on sort of the structure of the organization.

Rep. Keith Ammon (00:10:45):

We do have one question,

Rep. Michael Harrington (00:10:47):

Eric, I just couldn't not mention this. You gave your whole little spiel there and not once, did I hear the term environmental justice? Is this because of your audiences New Hampshire or is because it's not as important as some people think to ISO?

Eric Johnson, ISO-NE (00:11:04):

Well, it's not a part of, I can't commissioner, I can't quite read the room in the camera angle we're looking at, but the environmental

Rep. Keith Ammon (00:11:19):

If that's out of scope, we can move on to another question. No problem.

Eric Johnson, ISO-NE (00:11:25):

So that's something we could come back to if there's time. So any other questions on the organization? So let me jump into the three areas of responsibility and left to right. These are in the order that we were given these responsibilities. So prior to the formation of the ISO, the grid was operated by NEPEX, which was an arm of the New England Power pool. They had day-to-day responsibilities going back to the 1970s to operate the bulk power system. And we were given that responsibility. The markets did not exist in 1997, but FERC gave us the charge to create competitive wholesale markets and those were introduced in 1999 and subsequently we were given responsibility, sole responsibility for planning the transmission system, but backing up to grid operation, this is responsibility for the bulk power system. So these are the higher voltage transmission lines, the larger poles, typically these are the ties to our neighboring regions in Quebec, New Brunswick, and New York.

(00:12:45):

So we're managing not just the internal New England generation and transmission, but our connection to the eastern interconnection through New York, Quebec, and New Brunswick. If there's some type of a local outage in York community, a power outage that's typically happening at the distribution level that's not really visible to the ISO. So we're really just looking at bulk transmission system and the backbone of that system is 345,000 volts or we refer to that as a 345 KV transmission. The market administration function is the responsibility to provide a market trading platform. So the ISO is really not a buyer or a seller. We don't buy electricity, we don't sell it. We provide opportunity for companies that generate for companies that maybe are suppliers who are in the middle between customers and the generators and demand response resources to participate in the market. And there's pretty extensive oversight of the market to make sure there's assurances the markets are competitive and that there is no exercise of market power.

(00:14:09):

That oversight happens internally with an internal market monitor that reports to our board. There's an external market monitor, also reports to our board and then FERC looks very closely at the market here, not only New England but across the other ISOs and RTOs. The third area of planning, we'll touch on a little bit more for this discussion today, and this is making sure that the transmission system can support the demands that we forecast. We look out 10 years to make sure that the transmission system would be reliable. For many years the demand has been flat. A large part of that phenomenon is the energy efficiency resources that the states in New England have invested in, which has essentially moderated the growth in electricity demand. Although over time we expect that will grow as electrification builds demand for transportation and buildings and heating. But within the transmission planning space, we're also responsible for interconnections.

(00:15:18):

So I'll just highlight a few things that we don't do because I think there are some perceptions or misperceptions about the ISOs role in the region. We do not have any relationship with retail customers, so any policy around what individual customers pay for electricity, whether it's from a competitive supplier or the incumbent utility, that's all decided largely by the public utility commissions. The ISO has an operation based in Western Mass. We have a backup facility in Connecticut. Those are the only two assets that we own. We have no equipment in the field, we have no crews in the field. We work closely with the generators and the transmission companies that own those assets. But the ISO itself is not an owner of any assets on the grid. I mentioned we don't have a financial stake in those companies. We're also responsible only for the electric transmission system.

(00:16:17):

So you may have heard a lot of discussion over the years about the ISOs monitoring oil inventories or gas pipeline flows or LNG shipments. That's to give us situational awareness, but we don't have any jurisdiction over anything on the fuel side. So if a generator commits to produce electricity in the market, really their responsibility to make sure they can procure the fuel that they'll need to fulfill their commitments in the market. And then finally, on the sighting side, when resources are developing and they seek to connect to the grid, we handle the interconnection process, but we don't have a role in sighting for any types of generation, whether it's gas-fired generation, offshore wind projects, wind that's on land. Those are all the responsibility of the developer. We zoom out, you can see New England's part of a much larger transmission system. The eastern interconnection, we are tied to Quebec.

(00:17:18):

So while we are neighbors, we have only DC or direct current transmission to that interconnection. That's requirement of Quebec. But we do have connections to the Maritimes directly as AC transmission. So when something happens on the power system, this is a large AC system, one of the largest AC systems in the world. If a grid operator loses control of the system and there's an outage at the bulk transmission system, that can cascade pretty quickly to other parts of the system. And we saw that in the blackout 2003 and since then the reliability standards, which at one point were voluntary industry standards are now mandatory for reliability standards. If we zoom into New England, we have about 350 power plants that we dispatch. And by dispatch I just mean we're giving them instructions day-to-day for when they come online, when they ramp up, when they ramp down, and when they go offline. In total that's a little over 31,000 megawatts of iron in the ground for generating capacity just in New England. We'll talk a little bit about what's proposed in our queue. We've seen significant retirements. Most of that has been coal. Some oil has retired and significant amounts of nuclear also have retired in the system. And I mentioned earlier that demand resources also have opportunities to participate in our markets.

(00:18:54):

So if we think about the resource mix and how it's changing, three snapshots in time here. 2000 is the beginning of the competitive wholesale markets. 2022 is the last full calendar year that we have data for, and 2040 is a snapshot of the future. It's based on a decarbonization roadmap that was adopted in Massachusetts several years ago and it had some assumptions for all of New England in terms of development of clean energy. And so we've used that as just a reference. So it's not a prediction of what 2040 will look like, but it is a scenario so left to right, we've seen the percentage of energy from nuclear dropping. If you look to 2040, we expect that will shrink, although that still assumes we have the same amount of nuclear generation. It's just that other resources will be making up a larger part of the energy mix. Most striking in this map I think or chart is that coal and oil have fallen from about 40% of our energy combined to fractions of a percent. And we don't expect that that will be on the increase at all. Eventually these coal and oil plants are going to retire and the one remaining coal plant is in New Hampshire. So it only runs typically on really cold stretches, a period potentially in hot weather as well when the system has really high demand. So natural gas is yes.

Rep. Keith Ammon (00:20:28):

Eric, we have a question for you. Sorry to interrupt you. Mike Harrington.

Eric Johnson, ISO-NE (00:20:32):

Yeah, go ahead.

Rep. Michael Harrington (00:20:32):

Yeah, Eric, I'd looked at your books, hear me here. Looking to the future, I guess this is, you said it's kind of not a forecast but a projection or whatever. You assume that there's no new nuclear plants being built in New England over the next 40 years?

Eric Johnson, ISO-NE (00:20:49):

Yes, that's correct. Yep. Now you could modify that assumption and say that there is a case for the development of nuclear that would change this, but the study that is based on the future grid reliability study did not have an explicit assumption about expansion of nuclear.

Rep. Michael Harrington (00:21:10):

Thank you.

Eric Johnson, ISO-NE (00:21:12):

Okay, so gas is made up most of the energy on an annual basis there. If you look at the ISO real-time data on either the mobile app or the website, this could be 50 or 60% on any given day, just depends on what the demand is on the system. Hydro and imports are relatively stable over time. Imports would grow as you add more import capability and then renewables in the 2040 timeframe would have to make up a much larger share. And many of the state goals in the country in New England are tied to 2050 as sort of the final timeframe. And so the amount of renewables or clean energy or potentially nuclear in the 2050 timeframe would have to be even higher. So this is again just a snapshot looking at 2040.

(00:22:11):

If we think about what's been proposed to connect to the system, this is our generator queue. This is all public data and we show 38,000 megawatts of resources that want to connect to the system today. This is largely wind and more recently battery storage has become a big part of mix followed by grid scale solar, and you'll see there's just a small sliver of natural gas that's proposed. Gas fire generation, if you back up five years or so, you can see it's been a big change because gas dominated what's in the queue followed by wind. There was no battery storage in a standalone category, I think it might've been in the other category, but this is all driven by policy in the New England states, primarily Massachusetts, Connecticut, and Rhode Island providing incentives for these resources. So if you think about this shift, we're already seeing a transition in the types of technologies.

(00:23:19):

So when we think about the queue, queue is a term for like a line. You go to the deli, you get a number, you're in the queue. So we study projects that apply to the ISO to connect to the grid. We're not looking at the business case for a project. We're not looking at with how would this change the resource mix? Is this a good technology for the region? We're not looking at is this the best place on the system to connect? The developer comes to us and say, we want to connect this project to this part of the system. We study that from a reliability perspective, and the test essentially is to make sure that connecting that resource to the grid would not create an adverse reliability impact to the grid or other assets that are connected to the grid. So it's in effect a do no harm test and we'll walk through the different steps, but all of the projects in the queue are not necessarily going to get built.

(00:24:20):

I mentioned earlier we have about 31,000 megawatts of installed capacity in New England. Here we're looking at 38,000 megawatts. So we don't expect that all of this will get developed. Some of it is speculative. Some developers may have multiple projects in different locations on the system. It really comes down to three things that are needed. One, you'll need an interconnection approval by the ISO to connect to the grid, but a resource would also need to secure financing and they'd have to get permitting. So the developer has to sort of manage all three of those pathways. There's not a requirement that they do them in any particular order, but most of what's in the queue now is driven by state policy. And just a reference to the interconnection itself. Today, if a resource wants to connect to the grid, they pay for any transmission upgrades, whether it's a transmission line to connect to the facility or upgrades that are required in the area, that responsibility falls on the developer. There's no regional cost sharing for that interconnection. So it's different from if the ISO identifies a reliability need in an area and that gets developed, then the region would share the cost of that. But merchants currently bear responsibility. Now, there's a big discussion about this nationally and there's a move to have the cost of interconnections shared more broadly, not just across states but across the country. So we won't get into that too deeply, but today the standard in New England is the developer pays for the transmission to interconnect.

(00:26:09):

So we think about this energy transition that's underway and we've already seen it big shift from coal oil to natural gas, but as we look to the future, we're going to need pretty significant amounts of clean energy on the system. I'm not sure we showed in this presentation, but our forecast for the demand on the grid is essentially going to double in the summertime and it'll be triple what it is today in the wintertime. By the time you get to 2040 and 2050, assuming that the electrification goals for the states, for transmission, for transportation and buildings and heating are realized.

Rep Doug Thomas (00:26:49):

I've got a question. This is Doug Thomas.

Eric Johnson, ISO-NE (00:26:52):

Yes, go ahead.

Rep Doug Thomas (00:26:54):

Going back to your previous slide, my question is the chart you said that represents current policy, your mission is to focus primarily on reliability. We all know right now that looking at this chart here, none of those areas can be considered to be terribly reliable, and yet the small sliver of slice for natural gas is the only dispatchable fuel that would be reliable. So when you come around to looking at these projects, I know you're not considering the expense per se, but these are terribly expensive projects here and would be to the consumer. When you look at these projects, how are you factoring in the reliability when you know that wind and solar is not reliable and battery storage at best can provide only a few hours of backup, maybe a day or two at the most, and having a small amount of natural gas as your backup dispatch, how is it going to factor into approving the projects for your main concern of being reliable?

Eric Johnson, ISO-NE (00:28:08):

Oh, it's a very good question. So the queue process itself won't address that. There are other reliability standards and factors that we look at separate from this process. So I wouldn't hang reliability entirely on the queue. I wouldn't say that wind is not reliable. Wind is a variable resource, so it's weather dependent. We have forecasting ability so we can anticipate the output from the wind. We've done some pretty extensive studies of that phenomenon. So we know with met towers for future resources, meteorological towers, and then once projects come in service, we'll be able to predict pretty good what the output would be for the wind, especially if it's offshore. There's a much more constant wind than there is onshore. You're certainly right on the battery storage. These projects are primarily lithium ion technology, so they have ability to charge and discharge over the span of a couple of hours.

(00:29:18):

So that'll help for a short period. It certainly is not long duration energy storage, which we'll need ultimately to balance the system with lots of wind and solar and the solar resources. We have really good data on the production from the existing facilities and we have pretty good ability to forecast that. So I wouldn't put it in the category of reliable, unreliable. It simply has different operating characteristics. Now this figure in the middle, 38,695, that's the nameplate capability. That's a maximum output of the sum of all of these projects. When we buy capacity in New England through the capacity market, we're not going to pay a hundred megawatt wind project as if it can produce a hundred megawatts all the time. So every resource has to qualify in the market and the capacity value for wind is probably in the 30% range. That's one of the ways that we account for the different characteristics. You would have to build a lot of wind and solar to get the output of maybe nuclear or natural gas. But the states, the Southern New England states in particular are certainly driving for these resources to come in to the system. Representative, does that answer your question?

Rep. Keith Ammon (00:30:49):

Can I ask a quick follow up? Great follow up, yes. What if the forecast is that the output for wind and solar is diminished for extended period of time? What do you do in that case? Natural gas?

Eric Johnson, ISO-NE (00:31:06):

Are you talking on a sort of day-to-day basis?

Rep. Keith Ammon (00:31:09):

You mentioned your ability to forecast wind and I'm assuming solar, if it's daytime and it's sunny, what if the forecast for those resources is diminished for a period of time? What's the backup?

Eric Johnson, ISO-NE (00:31:27):

If you think about we don't have a lot of wind today. We have a lot of solar. So think about the solar. If you expect to get a high production from solar on any given day and then you get a cloud cover that comes in, the demand will still be there. It just means that you're going to sort of revert back to whatever is available on the grid. And for the most part, that's natural gas. So the gas fired plants are going to ramp down when there's lots of solar production and they'll ramp up when the solar production is diminished. And it's essentially the same for wind. Now I say natural gas because those are the current flexible resources. Over time you could see other technologies develop. You could see long duration storage in some form, and that would suddenly be the balancing resource for solar and wind.

Rep. Keith Ammon (00:32:24):

Okay, thank you. Another question, representative.

Rep. Michael Harrington (00:32:28):

Yeah, Eric, let's get a little more specific. Let's say it's 20 years from now and all these projections on offshore wind up to, I've heard up to 20 gigawatts of offshore wind is out there and we've got all sorts of solar, but it's the end of December and a northeaster comes up the coast and it snows for a couple of days and the sustained winds are 50 to 60 miles an hour off the coast covering the whole Gulf of Maine and the whole area of most of these wind. So the wind goes to almost zero offshore, we get almost no solar because it's the end of December and it's snowing out. How much backup are we paying for to cover those days?

Eric Johnson, ISO-NE (00:33:09):

Well, if you think about the existing fleet 20 years from now, so you could assume that the nuclear generation would still be available assuming it has not reached the end of its life. The gas fire generation certainly could still operate. So you may add incremental imports from Quebec, which is another source of energy. And you may have some type of long duration energy storage. So it might not be that you're only using the existing gas fired fleet, but you certainly are moving to a system that's highly weather dependent. And weather could be not just there's no wind, but it could be there's no wind power because the wind's too strong. You pointed that out, the high speed cutouts. And unless people clear off the solar panels, you're not going to get production from those facilities as well. So you, you're always going to need balancing resources to account for the variability.

(00:34:19):

But the other aspect among the four pillars that we talk about is you need energy adequacy. You need to make sure there's always enough energy in the system to account for those types of scenarios. And we haven't planned the system for 20 years out, but we do use the data that we have and we look at the queue to give us projections of what the system might look like, and then we're going to need other energy sources for those periods when wind and solar are not available. Now you're talking about probably days in a year when that may happen. So you're not talking about normal operating circumstances, but you certainly will need energy in that timeframe or you're going to need to find ways to reduce the demand, which is sort of the least desirable approach.

Rep. Keith Ammon (00:35:09):

Eric, we have another question in the room. Just introduce yourself.

Marc Brown (00:35:13):

Eric, Marc Brown, consumer Energy Alliance. How are you? I won't belabor this point.

Eric Johnson, ISO-NE (00:35:17):

Good, Marc.

Marc Brown (00:35:18):

But it sounds like, and we've heard this discussed throughout the country based on, but if you look at that queue current technologies, you're almost looking at two separate grids. Is that reasonable to say if we're going to pursue these public policy goals?

Eric Johnson, ISO-NE (00:35:37):

Mark, I'm not following you entirely. Maybe just to elaborate on your point.

Marc Brown (00:35:42):

Well, you're such you're going to need one grid that functions when the weather is right and a separate grid to function when the weather isn't, I guess is the way I would look at it.

Eric Johnson, ISO-NE (00:35:53):

Well, when I think of grid, I think of the transmission system. So that will be the same for the most part. But it maybe sounds like you're referring to the backup types of resources that Representative Harrington was talking about. So yes, if you're adding wind

Marc Brown (00:36:12):

Generation mix right, you're going to have two separate generation mixes, I guess is the way I would look at it.

Eric Johnson, ISO-NE (00:36:18):

Okay. Yep, I understand you. Yes, you will need to have sufficient backup resources to meet the demand. So that's just the reality of adding lots of weather dependent resources.

Marc Brown (00:36:39):

Okay, thanks. That was it.

Eric Johnson, ISO-NE (00:36:43):

Okay. Alright. So I mentioned the first two energy adequacy, making sure that the energy supply is robust in all circumstances. And then lastly, we'll need transmission to move power around the system. So not just interconnecting a wind farm or some other resources to the closest point on the transmission system. That's not always where the load or the concentration of customers happens to be. So you're going to need to move power across New England. So we expect there's going to be significant transmission build outs. And we've done a study, we have a study underway that's referred to as the 2050 transmission study, and it takes the electrification goals that are in place for the states and does some forecasting out to 2050. And much of the transmission system would be overloaded. About half of the circuit miles would be overloaded to serve that future peak demand. Again, when we are shifting back to being a winter peaking system in the region. And so that would require upgrades of existing lines. That seems to be the path of least resistance compared to building new transmission in new rights of way. But this future system will require significant transmission investments and we're happy to share the results of that study. The report will be out in draft next month.

(00:38:17):

So jumping to the queue, this is sort of a high level diagram of the pathway. So starting on the top left in the purple, a developer has an interconnection and request. They provide basic information about the size, the location, the fuel type is just so we can understand the technology. We're not concerned about that because we're supportive of the fuel or not supportive. It just helps us understand what type of resource it is. So the first study that's an option is a feasibility study. It's a high level conceptual assessment of the project and it can be at one or more interconnection points. So the cost of this study is significant for us if we were writing the check to pay for it, but it's a relatively inexpensive component of the queue process. The next element on the green, on the top right, the system impact study, this is really the heart of the queue study process.

(00:39:27):

So the ISO would identify exact upgrades where the developer wants to interconnect, and this is referred to as the SIS, system impact study. Some developers may do the feasibility study first, wait for the results on that, and then move forward with the system impact study. The cost of the system impact study are significantly higher. So if they gauge the results of the feasibility study, that may inform where they want to go for the next phase. Some developers might say, I'm all in on this project, on this location. I want to start the feasibility study. I want to start the system impact study. Get that going right away.

(00:40:10):

Once we've crossed through the SIS study, the facility study will provide detailed cost estimates of the upgrades at that spot, and that essentially completes the technical study work. But there's also an interconnection agreement that's required, and there's three parties to that. It's the ISO, it's the resource that's interconnecting and the transmission where the resource wants to connect. So you can't connect to the grid until there's an interconnection agreement among the three parties. And the procedures for that are specified by FERC. So there's what they call proforma agreements for a lot of the interconnections. And the resource then goes into the process of construction testing, making sure that gets wired into the ISO market system so it can receive dispatch instructions and also revenue quality metering so that the resource can be paid based on its output. So the study process can take 15 months, 18 months, two years in some cases depending on where the project is on the system, if there's a lot of other projects being studied. So this is sort of the traditional queue process. And there's a link to a more detailed training overview on this slide.

Rep. Keith Ammon (00:41:36):

Question, Eric.

Rep. Michael Harrington (00:41:40):

Eric, this process you've showed out there has worked well and it worked well with, we had policies in New England where we basically fuel neutral as the ISO says they are. But we are going forward where we're now having states like Massachusetts telling their public utilities, you will go buy some wind offshore wind, you have no option. And of course when they sign a PPA with that, then they bid into the market at zero and it tends to lower the clearing price, which sounds like a good idea until we drive some other resources out or one that may come in. That's more what you call balancing, I call dispatchable, that won't get built because they look at the prices as being too low because of the subsidies. So where does the ISO come in and say for reliability purposes, if we add these additional amounts of intermittent resources that are going to drive the prices down in the energy market, it's going to make the market unreliable. So we are going to go back to a whole mess of RMR plants, or is there going to be something that the ISO is at least looking to the future on saying we're going to have to change how we do business?

Eric Johnson, ISO-NE (00:42:53):

So Michael, you are asking a question that would really zoom out, ask what's in the queue process? The queue process doesn't look at markets or market implications or the policies that are driving resources in. So every project needs to go through the queue, whether they have support from an outside contract or a state policy or it's a merchant, it's the same

Rep. Michael Harrington (00:43:25):

But just my point is that that works presently and it worked in the past. My point is we go to the future where we're going to have mandated purchases of large amounts of wind and solar for states like Massachusetts, Connecticut, and Rhode Island. I think the process is going to have to change because you're going to look at this and say, okay, they passed all these boxes, great, but now the system's become unreliable because we're not getting any new, I'll use your term balancing resources and some of the ones we have closed because the energy prices just aren't high enough to keep them going. So then you say, well now we have an unreliable grid because we're adding all these intermittent. So somewhere along the line, the ISO is going to have to say, can't take on any more wind because it's not reliable enough or can't take any more solar. Somehow that's going to get worked into the future here, especially if you're talking about tripling the demand. That's a little,

Eric Johnson, ISO-NE (00:44:19):

So Michael, let me,

Rep. Michael Harrington (00:44:20):

You don't have to answer the question.

Eric Johnson, ISO-NE (00:44:21):

I appreciate, I understand, I appreciate that. Let me get through a couple other slides and we can come back to that if it's not further addressed. So when we think about the queue, there's really, there's a couple dimensions to this. There's generators that want to connect to the grid within New England, and then there's transmission that wants to connect to the grid in New England, but the source of the energy is outside of New England. So that involves transmission. And typically you think of a project from Quebec into New England, the New England Clean Energy Connect project from Quebec into Maine as an example of that. We call them electric transmission upgrades or ETU. So we're studying both of those in the queue space generation in ETUs. We're also not making any judgements on the benefits of the transmission side projects. And I mentioned the three parties to the agreement.

(00:45:26):

If you think about the timeline for resources to come online, there's also two jurisdictional dimensions to resources. So we administer projects that want to connect to the bulk power system and engage in wholesale market transactions. So we call those FERC jurisdictional, those are the ISOs responsibility. We administer the queue process, we establish timelines and milestones, and the average study time is around 15 months for that. And if they complete that process, then they can proceed to commercial operation. If you look in the bottom, there's non FERC jurisdictional. These are projects that want to connect below the transmission system. So they'd be connecting on the distribution system. The ISO has no jurisdiction here, so you could think of rooftop solar as an example. So they would go through a state, jurisdictional state, meaning the public utility commissions typically provide the regulation of those types of interconnections.

(00:46:32):

It's different for each state. Their timeframes vary, but then those resources can come into commercial operation. What is in the middle is the forward capacity market (FCM), and I think this gets to what Representative Harrington was talking about. So a resource could go through the queue and become operational without touching the forward capacity market if they don't want to offer to sell capacity and get a capacity supply obligation and just take the revenues that they can earn out of the energy market or one of the other reliability markets. Most resources do, however, seek to qualify to be part of the capacity market they offer into one of the annual auctions. And then if they clear if they're among the lowest price resources, they would get what we call a capacity supply obligation or a CSO. And that would provide another source of not only capacity for the ISO, but a revenue source for that resource. And we could see resources that come through the ISO queue participate in the capacity market, but they're also smaller resources in aggregate on the state interconnection queue that might participate in the FCM as well. Although historically, most of the resources in the FCM are on the FERC jurisdictional side.

(00:47:57):

This is just for the benefit of us seeing each state's breakout of what's in the queue. Most of it is offshore wind in Massachusetts. So they have most of these resources and a lot of additional information available about the queue process where it fits within our tariff, the high level guides for each resource that wants to interconnect what we call the public queue. There's a tracking tool so anybody can pull up at any given time. What is in the queue, what's the mix, how has that changed over time? And if you wanted to participate in the capacity market, there's a specific section of our website and the team here and training materials for that as well. So I'm sure I'm over to the initial time, but I'll pause there and see if there are other questions.

Rep. Keith Ammon (00:48:54):

Yeah, thank you for, I'll take the blame for not scheduling enough time for that presentation because it had a lot of information. Let's try to get to our next speaker within the next three to five minutes, and that would be Tristan from Moltex. So just to let Tristan know he's up next. We have a question in the room if someone could pass the mic to Representative Thomas.

Rep Doug Thomas (00:49:20):

Thank you again, Doug Thomas. So I saw in your last slide, now I was thinking about it during your proposed slide. As you know, there are at least a couple of proposed hydro power projects that are being thought about and yet they constitute a, according to your chart, a minuscule percentage of generation. But does that factor into these projects in terms of whether they will be worth going through the expense and siting of putting something in that contributes according to your chart, so little to the grid? Or how are these hydro projects going to be looked at overall?

Eric Johnson, ISO-NE (00:50:12):

Representative, when you say hydro projects, are you talking about imports of hydropower from Quebec as an example? or,

Rep Doug Thomas (00:50:20):

Yes. Yes. Hydro generated that would be imported through New England.

Eric Johnson, ISO-NE (00:50:28):

Okay, thank you for the clarification. So we have a significant amount of run of river hydro in New England. They're actually some of the oldest resources, but we're not expecting more of those. So when we think about additional hydropower, it would be one of the elective transmission projects that would bring additional power into the system. When you saw the slide showing at a relatively small part of the mix, it could be, but we could add 1200 megawatts or more of import capability with any one line. So that would be a significant source of power, even though relative to the overall energy mix, it might look small.

Rep. Keith Ammon (00:51:19):

Great. Any questions online? We'll give you a few seconds to raise your hand by Zoom. And while we're waiting for that, I just want to recognize we have a couple of commission members online and that would be Chris McLarnon from UNH Professor of Physics and David Shulock is the general counsel for the Department of Energy. They're both online. Alright, seeing no questions online, Eric, we thank you very much for that presentation. I may be reaching out to you if we could get a copy of those slides that might be helpful for our group. And it sounds like we may have a bunch of further questions, so we'll try not to bombard you too much with questions about the ISO.

Eric Johnson, ISO-NE (00:52:08):

Appreciate your time

Rep. Keith Ammon (00:52:09):

And Nathan, thank you for helping to schedule this.

Eric Johnson, ISO-NE (00:52:13):

Alright, thank you.

Rep. Keith Ammon (00:52:15):

And you're welcome to stick around or drop off, whatever you prefer. Alright, next up we have the vice President of Corporate Development for Moltex Energy, Tristan Jackson. And Tristan, thank you for, we had some frustration with the Zoom link not working. I have to go back and check. Maybe I put the wrong link in a different calendar invite. So thank you for sticking around and working through that with us. And Tristan, feel free to share your screen if you have anything to present and welcome to our commission and please go ahead with your presentation.

Tristan Jackson, Moltex (00:52:57):

Thank you very much. Thanks everyone for inviting me to speak with you today. And I do have slides, however, I much prefer conversations to presentations, so I'll only use the slides if you guys ask me to. And I'd rather tell you a little bit about what we're doing and hear your questions and just respond to what's in the room. The reason that's my preferred approach is that whatever I might have to tell about or might think that you'd be interested in isn't actually what matters. The only thing that actually matters is what you want to know about what we're working on or what I might be able to tell you. So I'll give you a little introduction to myself and the company I'm with today and what we're doing and then we'll see if you all call on me to put up the slides or have questions.

(00:53:49):

But from there, I'm actually in Maine today though I'm based in New Brunswick, Canada most of the time. And New Brunswick is the headquarters of Moltex Energy Canada. Quick point of clarification there by the way, because I saw on the invite there was a note on Moltex being a UK company. There are two Moltexes, there is a UK Moltex and there's Moltex Energy Canada. They have the same parent co. Moltex Energy Limited is the holding company of the two wholly owned subsidiaries. And it's set up that way because Moltex Energy Limited owns some of the key intellectual property that both of the two actually active companies with teams doing things are using. But they're very different. Moltex in the UK is developing a 16, like one six megawatt. So small micro reactor really that will use fresh uranium as fuel HALEU is what they plan to use high assay, low enriched uranium.

(00:54:58):

And that's good because you can put it anywhere, it's bad because the world supply of HALEU is very constrained these days. So we'll leave that for later if there are questions about it, but Moltex Energy Canada, very different. We're developing a waste burning reactor. The drawback of that is that you'd only put it where you have used fuel to recycle. So you need a conventional reactor to have done the once through fuel cycle that is used by all reactors today. The Gen II reactors, this would be a Gen IV reactor, so different fuel form and different coolant than say like what you have in New Hampshire at Seabrook. But the fuel that goes through the Seabrook reactor I'm sure is all still stored on site. What we're working on doing is taking that used fuel, separating it into three streams. One of those is then low level waste.

(00:55:54):

Half a percent of what we started with is still high level waste, but short-lived with a 300 year half-life as opposed to 300,000. And then the other stream is what we would use as fuel. And that's a mixed plutonium chloride fuel salt that then goes into a molten salt reactor. And drawback is you need used fuel to want one of these. But then the pros, the positive side is that it greatly reduces the used fuel liability, which is otherwise there's a cost of disposal or storage for that and it can produce about half as much again, clean power. So you've got a 1.2 gigawatt plant, at Seabrook, we could do about 600 megawatts of waste burning reactor that would run for about 60 years on the used fuel supply that I'm thinking that you have there now since it's been running since about 1990. So Moltex Energy Canada is where I work.

(00:56:55):

It's the waste burning reactor, not the flex reactor that is being done in the UK. It really only belongs as an add-on to an existing nuclear power plant. So it's not one that you would site where you had say an industrial load to serve, but it's good in that it's a grid asset goes, usually you'd picture it within the same approved nuclear boundary of an existing plant, reduce the fuel waste liability and add about half as much again clean and baseload and dispatchable power to the grid. So I'm from Maine originally. I'm in Maine today visiting family and so have been a close neighbor of New Hampshire for a long time. And one of the things that I really like about New England and New Hampshire is the sort of fierce independence and autonomy that we all seem to believe in around here. And the ability to have energy supply security within state borders I think is something that we could all appreciate greatly.

(00:58:04):

And I do have concerns with some of the plans for grid development. I think the poster child of what maybe not to do is Germany these days. If we look at the amounts of investment they put into renewable energy around 500 billion over the last 10 or 20 years and where that ended them up, which is about triple the average cost of electricity from the European Union average, their carbon intensity is around 360 grams of CO_2 per kilowatt hour. And they completely failed to reach energy independence with that approach. If they had spent the same amount of money on new nuclear, they'd be at zero carbon emissions today and they could have complete fuel supply security stored onsite for hundreds of years if they wanted to. Ontario is kind of contrast in the other direction. They have about 60% of their primary energy mix is from nuclear. Carbon intensity is around 24 grams of CO_2 per kilowatt hour, so order of magnitude less, and the cost is around 12 cents compared to Germany's 40 cents a kilowatt hour so far more affordable, much lower carbon emissions and not reliant on unfriendly neighbors. Ontario has other advantages that Germany doesn't, but sort of similar latitudes. And if you think about solar, it can work pretty well in states like Arizona, but it's not so great for places like Ontario, New Hampshire or Germany.

(00:59:45):

I grew up on an off-grid island. First home I lived in out there was we had a standalone solar plus storage system is what you'd call it today. But really it was a deep cycle, marine battery, a couple of solar panels we'd salvaged and it was heated with wood, very basic sort of back to the land lifestyle and raised kind of by hippies and squirrels. So I was the last person that anybody thought would become an advocate for the nuclear industry. And I have worked on sustainability and decarbonization pursuing an all renewables path for over 20 years and just ran into the impossibility of doing that. So anyone who spends enough time trying in the real world as opposed to trying say in an academic bubble with a model and spreadsheet magic, we'll run into physics. And I'm just not seeing a world that is going to decarbonize with renewables alone or even with a primarily renewable approach.

(01:00:48):

So I do get concerned with some of the projections and plans that I see put forward. I don't think we want to be in the same boat as Germany in 20 years. And some of the questions that folks in the room are asking I think are spot on. One minor point of clarification, I think, and maybe Eric would agree, or I think we're using the same terms, but when we talk about reliability, that has a very specific meaning in the electricity world. It means the ability to avoid brief interruptions lasting less than five minutes. So that's a particular thing that happens when your resource mix isn't in the right configuration and you get reliability issues. Resilience is another specific term that means the ability to recover when you have some sort of massive event that knocks the grid out. And if you can bounce back quickly, that's a resilience.

(01:01:50):

Some of the questions that were about reliability, I think you might've meant what I would call resource adequacy. And that's do you just have enough generation assets over some period of time, a few days or a month or whatever it might be, coldest day of the winter, day of the nor'easter. Do you have enough resource adequacy to meet the load during that time period? And if not, then you end up, as Eric said, with the least desirable outcome load shedding or forced brownouts. So they're just two slightly different terms. Reliability, I think some people might've been thinking of that as resource adequacy, but if our plan in New England is to turn to say Quebec for resource adequacy, I'd be nervous there because Quebec has about a 37 gigawatt grid. And last winter they were importing, I think it was seven or eight gigawatts from Ontario using Ontario's nuclear power on their coldest days of the year when they had two problems, one on the hottest day, I think the wind died to nothing on the coldest day, it was too strong.

(01:03:01):

So in both cases, their renewables weren't performing and they didn't have resource adequacy themselves. And they got into a position where Quebec shut down Gentilly, their only nuclear power plant a little while ago thinking they had the world's greatest hydro resources. But as we've come to see, and not so much yet in Canada, Canada's got really good water. But in other parts of the world, Italy and Buenos Aires to California, they're having hydropower shortages because of just unpredictable rainfall and more extremes, sometimes too much, sometimes too little. And so hydro hasn't been as reliable as it used to be. And Quebec committed to sending a lot of power into New England. Then New England and New York in particular started shutting down nuclear power plants. And we're actually facing a bit of a generation shortage in Canada as well as projected shortfalls in New England. So I'm a very big advocate for nuclear power, not because I was born and bred in the industry, but quite the opposite.

(01:04:19):

I came to it almost kicking and screaming and tried for a long time to figure out how to decarbonize the world with renewables alone. But when we talk about Germany spending 500 billion to get to, I think they made to around 70% renewables penetration. And then you ask them what would it cost to go all the way to net zero? And they said $5 trillion more because of the amount of battery energy storage, they picture having to add. And then the additional renewable generation, because batteries are, not everybody knows this, right? They're not a generation source. They consume energy. When you charge them and discharge them, you don't get a hundred percent round trip efficiency. So they're actually a load on the system with a useful life of maybe 10 to 15 years at best as opposed to a nuclear power plant with useful life of 50 plus years. And there was a comment about capacity factor with wind, offshore, wind maybe being rated at 30% capacity factor while nuclear can operate above 90, Ontario's fleets around 92% capacity factor.

(01:05:35):

So anyway, that's a little bit about me, a very little bit about the company. We're working on fuel recycling. I do believe that's a good idea. One, because you get some harmful substance consumed in that process. It's kind of like a catalytic converter and a car exhaust or in a wood stove. By recycling, we don't, by the way, I should make sure that we're super clear on what is recycling, what it's not. It's not the best word because recycling, we think of things like recycling, aluminum can or glass or something. You take a material, you make it into a shape, you use it for what that shape is useful for, then you toss it in the melting pot and turn it into another shape. But material didn't change at all. That's not what we do with nuclear fuel recycling. So again, it's probably not the best word, but you take fresh uranium out of the ground, maybe you enrich it.

(01:06:33):

If you have kind of reactor that you have in New Hampshire, you need slightly enriched fuel. But then you put it through the once through fuel cycle and it has changed. Some of what was sile in there has fissioned, some of isotopes that were fertile have accepted a neutron and they've become a new element. So uranium 238 has gotten hit with a neutron and it's become plutonium 239. Now that's what we call waste, that stuff. And also when the fissile isotopes break apart, there are some small pieces, some of that is waste too. That's the short-lived waste. The transuranics or elements heavier than uranium is the long-lived waste, that long-lived waste. First of all, you got a disposal problem as is. And secondly, if a bad actor got ahold of it, you can put it through a very big expensive machine, a conventional reprocessing plant, and pull out the plutonium to a level of purity that allows you to make a nuclear weapon.

(01:07:34):

So you have a proliferation risk when you have used nuclear fuels sitting around. And if we take it out, not to that level of impurity, but as I mentioned in a mixed plutonium chloride, fuel salt, it's not suitable for a weapon, but it is suitable for fuel in a civil reactor. And that reactor consumes it. So when it's gone through that fuel cycle that quite dangerous material no longer exists and otherwise it has a half-life of over 300,000 years and for centuries will be available. It's kind of hard to, if you don't destroy it in a reactor, burn it, then you can't really lock it away to no matter how deeply you bury it, someone can always dig it up and use it for something that they shouldn't in the future. So again, a little bit about me, a little bit about the company and why I believe in nuclear energy in general and in nuclear fuel recycling in particular. So I'll stop there. I can show some of what I just went over on slides or I saw one hand go up. So what are your questions?

Rep. Keith Ammon (01:08:43):

We have some questions in the room and I think we're going to want to know a little bit more about your design and about the process of the recycling, but we have a representative, Doug Thomas, he's the vice chair of the House Science Technology and Energy Committee.

Rep Doug Thomas (01:08:56):

Thank you. Yes, Doug Thomas. First, just a comment before my question. From what I heard you say, we should be relying on Hydro Quebec import power about as much as we should be relying on weather dependent fuel in other words, it sometimes may not be there. If I catch your drift on what could happen during extreme events up in Canada, they may not be able to provide us with the fuel that the power that they promised us. I think we've see that happen on a couple of occasions, but my question

Tristan Jackson, Moltex (01:09:37):

Yeah, Go ahead.

Rep Doug Thomas (01:09:38):

Great comment. Go ahead. I was going to say,

Tristan Jackson, Moltex (01:09:41):

I was just going to say yes. Essentially yes, if you don't have your bread and butter in your own pantry, you're counting on your neighbor having enough to spare and sometimes they do and it's possible that they might not for their own technical reasons, not that they wouldn't want to, but that it might just not be there.

Rep Doug Thomas (01:09:59):

Right, thanks. My question is, did I understand you correctly on your process, would your process have to be close to a regular nuclear facility? For instance, suppose you wanted to use Seabrook, would you have to build a facility near Seabrook in order to use their spent fuel or would you rely on wherever your facility is to have a plant transport that fuel to your facility?

Tristan Jackson, Moltex (01:10:27):

That's a great question. I'm glad you brought that up. There are two ways to go about it and the more economically efficient way is to build one large recycling facility, take all the used fuel there, recycle it, and either use it there or send the new fuel, the salt form of the fuel to wherever it's wanted. That would make the most sense in monetary terms, economies of scale build a large recycling facility, but there are problems when it comes to moving that stuff around and so for that reason you may find it easiest to get social license to operate if the radioactive material doesn't leave an approved nuclear site. So our first-of-a-kind is planned to be built at the Point Lepreau Nuclear power station in New Brunswick. That's about half the size of the one you have at Seabrook and it's a different type of reactor.

(01:11:26):

You have a lightwater reactor, they have heavy water reactor in New Brunswick. All the reactors in Canada are that heavy water reactor CANDU technology, so slightly different plant but 650 megawatt nplate capacity and with that we can fuel a 300 megawatt waste burning reactor for 60 years with their supply of waste. The plan is to build both the first recycling facility and the first waste burning reactor inside the fence of their nuclear site there at Point Lepreau. Now we are building the recycling plant oversized for the reactor. The reason for that is that you need a seven ton fuel load to go in the core for it to go critical the first time, but then after that it only consumes half a ton a year. So if we built it to the operating size, it would take us 14 years to build up the first core load.

(01:12:27):

So we're not going to do that. We're building it, the first recycling plant scaled to develop a seven ton core load in just two years and then that means it's significantly oversized. It's got three tons a year of capacity sitting idle for the rest of its useful life unless we could bring used fuel from other places there and use that excess capacity to recycle it and send fuel back. We've talked with the DOE and with the US nuclear operators and with the operators in New Brunswick about doing that. On a practical level, I think everybody agrees that would make a lot of sense. Logistically international relations, the NNSA, the Nuclear National Security Agency, it's a little murkier as to whether or not that would be allowed. There's currently no export license granted to move used nuclear fuel out of the US so even though it's just a short way and back again, there'd have to be some new rulemaking to allow that.

(01:13:34):

Now we could build one large recycling facility in the US and US has about four times as much used fuel as Canada does and no approved site. I'm sure there's no approved site to do final disposal of the used fuel in the US since Yucca Mountain has apparently permanently failed - that plan. So we have talked with other nuclear operators in the US about whether we should plan to do recycling in Canada, whether we should put a recycling facility alongside each existing nuclear power plant or whether we should do a central location and move the fuel around. We think again for social license to operate it would be easiest to do the recycling and the waste burning right on site where they use fuel already sits and then you also typically you have a very good big strong grid interconnect right there. So that interconnection process and permitting should also go a little smoother that way. But that's still a bit of an open question.

Rep. Keith Ammon (01:14:40):

We have some other questions in the room. I'm a visual learner so if you have any diagrams for how your system works, I'd love to see that if you're willing to share. Represent Michael Harrington.

Rep. Michael Harrington (01:14:54):

Yeah, thank you. You're talking about these CANDU reactive as the primary source of the fuel, so you're talking heavy water with the next generation, whatever you are using that's fuel, whatever you want to call it. Would that also be a heavy water reactor CANDU design or would be?

Tristan Jackson, Moltex (01:15:10):

No.

Rep. Michael Harrington (01:15:11):

Okay. Would not be.

Tristan Jackson, Moltex (01:15:12):

No. So the heavy water and a CANDU reactor is the moderator. The reactor we're developing is unmoderated. Generations one, two and three. Generations one is no longer in use. Generations two are everything that's producing power on land these days. Generations three are what's in the nuclear submarines and aircraft carriers and they've started to build some gen III reactors on land now. Gen IV is different than the first three generations in that it uses a different fuel form and a different coolant and there's a bunch of different concepts that you'll hear I think from Ultra Safe Nuclear about probably like a TRISO pebble bed concept. We're using a molten salt fuel and molten salt as the coolant with the whole configuration with how it works, we don't need a moderator like graphite or heavy water.

Rep. Michael Harrington (01:16:13):

So excuse me, is this a fast reactor then of these thermal neutrons?

Tristan Jackson, Moltex (01:16:17):

It is fast. The breeding ratio ratio though is 0.6 so it consumes those transuranics over time. You can have a fast reactor with a breeding ratio of over one and then you'll be producing more transuranics through use. We're not doing that but the intent is to, sorry,

Rep. Michael Harrington (01:16:40):

Clinch River was supposed to be that never got built in the United States. Well, following up on the chemical processes.

Tristan Jackson, Moltex (01:16:45):

I want to see if I can share screen here since there was a request for visual. Is that working?

Rep. Michael Harrington (01:16:52):

Yep, that works for you. You're talking about taking plutonium 239. So if you're using CANDU fueled is going to be, well when it's burnt through the normal process you're going to have 238, 235 uranium and you're going to have plutonium 239. So you're extracting chemically the plutonium 239 And how is it that doesn't become a proliferation problem because at some point I guess you're going to get pretty close to just plutonium 239, which how do you make sure that doesn't approach weapons grade?

Tristan Jackson, Moltex (01:17:27):

Yep. So this is just a schematic and looking at a CANDU fuel bundle. The ratios would be a little different here for a lightwater reactor there'd be more of the fission products and the fuel salts and less of the uranium 238. That's what that should say. There's not just uranium but that's U 238 and zirconium cladding is the big blue box. That's the majority of the material When you start out a hundred percent of the fuel bundle is classified as high level waste and so all that needs to be very carefully handled and disposed of in a deep geological repository or something of that nature.

(01:18:11):

We do put it through a chemical separation process. So the traditional reprocessing, I've got a slide two that shows the different plants and what those look like is it takes a very big facility, it uses centrifuges, it consumes a tremendous amount of energy. It's a mechanical separation based on the very slight difference in weight between those different elements and with that you can pull out pure plutonium. Instead of doing that we rely on chemical differences between the isotopes. We take the whole fuel bundle and grind it to a fine powder and we put that through a three stage hot bath of salts and other chemicals that cause a separation into these three streams. So we get almost 99% is now low level waste. Uranium 238 and zirconium alloy cladding a half percent are those short-lived 300 year half life fission products. We don't have a use for them and 0.6% is what we use as fuel.

(01:19:25):

Now what is that? It's about 90% plutonium and about 10% other actinides. So the actinides of the rest of that row of the periodic table, these are elements heavier than uranium. They don't exist in nature, they're classified as waste. Some of them are fissile and we actually can use them as fuel along with the plutonium. Some are not and actually inhibit the chain reaction. They're in the form of a salt combined with a chloride. So that mix of 90% plutonium, 10% other actinides in the form of assault with chloride you would not be able to use to make a nuclear explosive device. It could do what they call a dirty bomb. Just blow that stuff up with some other explosive and scatter radioactive material around. So there's a little risk of that, but to take it from what it is when it comes out of our process and make it into what you would need to make a bomb, you would still need a reprocessing facility. So that's what that is right there. It's the size of a large airport, a couple of billion dollars to build one of those. You can't hide it. So if you go and build one of these things the world knows versus the recycling facility is the size of a hockey rink order magnitude cheaper and it produces this lower purity mixed plutonium chloride with other actinides, fuel salt, not a weapons usable material.

Rep. Michael Harrington (01:21:06):

One final question, what do you estimate the cost of your electricity being generated? What are you going to be able to sell it? What's the price?

Tristan Jackson, Moltex (01:21:16):

I'll tell you what the company says. Wait, where'd it go? I've got the wrong slide. Sorry. I thought I had a different slide in there. This is what it looks like and you asked about the cost. We have projected and not just us, this has been third-party reviewed by IDO S and c Laughlin and the Department of Energy that levelized cost of electricity, it would be $51 a megawatt hour. Now I'm going to raise my hand as Tristan not Moltex guy and say that's probably not going to happen, just to be clear. I don't want to mislead anybody. That is what the projections say. That is what the third parties have confirmed. The cost estimates are credible, but anybody who's ever built any mega project knows the budget's not what you end up with. So I would guesstimate based on my personal experience that we'd see it more in the range of $70-80 a megawatt hour, still competitive with say coal or gas and far more competitive than renewables plus battery energy storage, which is what to be the same thing, to provide the same grid resource you'd need to combine it with at least three times as much renewables and then a tremendous amount of battery energy storage, which is at least an order of magnitude more expensive than this approach.

Rep. Keith Ammon (01:22:44):

We have another question in the room. Dick Berry, he's the former chair of the House Science Technology and Energy committee and let me just say anybody online would like to ask a question, please raise your hand now.

Hon Dick Barry (01:22:55):

Thank you and thank you. Push in on this or can you hear me?

Tristan Jackson, Moltex (01:23:00):

Yeah, I can hear you.

Hon Dick Barry (01:23:02):

Okay. We had a gentleman before us who gave a forward-looking approach to energy and unfortunately nuclear was not included in any additions. I meant to ask him, but we got up too quickly. Do you know if they solicited any information from nuclear power people and if not, would you solicit a proposal you could get in a queue?

Tristan Jackson, Moltex (01:23:27):

I don't know that, but if I understood correctly, again from my own experience and what the ISO's job is and then what Eric said, no, what he was talking about that queue is what developers told them, Hey, we want to build this. So I don't believe that they went out and said world, we need this much of this and this much of that and some percentage of nuclear. I don't think that was in some kind of integrated resource plan that they put forward to the market. I may have missed something there, but I don't think that's what he was talking about. Could a state or a region come up with their own ask and say to the world we would like something like this? Absolutely. I mean that's why Moltex is in New Brunswick is because in New Brunswick there's just one utility NB Power, New Brunswick Power.

(01:24:33):

That utility is owned by the province. So New Brunswick effectively is the owner of their whole energy system and from the province passed down to the utility, the utility put out to the world a request for modern reactor concepts, advanced and small modular reactors. Over a hundred different companies responded and we Moltex and one other that goes by the name of ARC were selected through that process to come to the province and develop our, in both cases first of a kind reactors. So they were looking for something new and innovative and they chose us because of the value of fuel recycling along with the other characteristics of the company and the technology. To the best of my knowledge - now Canada, the US a little bit different - but could New Hampshire or the right cast of characters in and around New Hampshire say to the world we want to see some nuclear new builds here. I don't see why not.

(01:25:43):

Now the DOE is very bullish and encouraging toward new nuclear. I imagine most have seen the Inflation Reduction Act (IRA) included both in investment tax credit and very importantly a production tax credit for new nuclear. That production tax credit is the thing that protects against wholesale prices going to zero when intermittent resources have zero marginal cost of production and they're bidding power in at 0 cents and that makes it impossible for nuclear plants to operate competitively or any plant that has a marginal cost of production because it uses fuel and uses labor to run. And so the production tax credit that's in the IRA from the feds has put a floor on how low the price can go for nuclear generated power, super important and they're encouraging over a hundred gigawatts of new nuclear to be built across the country.

(01:26:44):

I see no reason why New Hampshire, New England couldn't be home to some of that and couldn't take advantage of some of the federal stimulus dollars that are coming behind nuclear just in this year. And really I think it was Ukraine that kind of turned the lights on for a lot of people that were like, whoa, we can't remain dependent on energy imports. We can't do an all renewables strategy and then still need cycling backup. We need to do something that will give us energy sovereignty and nuclear and also support decarbonization and nuclear is the only option for that as far as I know.

Hon Dick Barry (01:27:26):

Thank you.

Rep. Keith Ammon (01:27:29):

Just a question about the small land footprint, that 20 acres on the slide currently, does that include the recycle facility as well or is that just for the reactor?

Tristan Jackson, Moltex (01:27:39):

That's everything. So this is what it looks like. The reactors, the building in the front, the recycling facility is the one off to the right and then the blue tanks there in the back are grid reserve. That is a form of energy storage that is about a 10th the cost of lithium ion and can give you about a three day duration. It's molten salt. That technology was developed by the concentrating solar power sector and it's suitable. You can store energy as heat much more cheaply than you can store it in batteries. If you have heat to start with. It doesn't work very well to take renewable power, turn it into heat and then bring it back to power. But if you've got a reactor running, it does this. Basically you have a 500 megawatt reactor charge up a gigawatt worth of thermal energy storage for two thirds of the day and then you have a dispatchable one and a half gigawatt worth of peaking power.

(01:28:52):

So you could set this up in either a baseload configuration or a peaking power configuration with this grid reserve addition to the plant and that is, that whole thing is on 20 acres. So how it looks alongside Point Lepreau is over a hundred acres site there and the boundary electrical boundary, or sorry nuclear approved site boundary is way out beyond the facility that you see. So that little white square is the size of a Moltex recycling plant, waste burner reactor plus grid reserve, and it would all fit inside the fence of the approved nuclear site alongside this 650 megawatt CANDU.

Rep. Keith Ammon (01:29:38):

That's amazing. If you could just walk us through when you are done with whatever fuel you end up using, what happens to that? Where does it go and where is it stored?

Tristan Jackson, Moltex (01:29:49):

So there's two steps. First coming out of the "Watss" is what we call the recycling plant. It stands for waste to stable salt. You take a used fuel bundle from a conventional reactor and you put it through Watss and you right there have three different streams. One of them is the fuel that's going into the waste burning reactor. Half a percent of what you started with is a high-level waste with a half-life that's three orders of magnitude shorter than what you started with. So you've gone from 300,000 year waste to 300 year waste, but you still have that half percent of high level waste and you still need to either very securely and safely store it at surface the way it's stored at site in dry casks now. Or you need something like a deep geological repository or an alternative option with, because there's so little of it, it can be cost-effective to put it into a borehole.

(01:30:46):

That's a very deep hole. There's Deep Isolation is the company in the US that's working on that technology. So you still have a little bit that needs disposal as high level waste and very careful handling. The large majority coming out of Watss, the 99 almost percent of it is low level waste. That means you can't make a weapon with it. You can put your hand on the container. It's safe enough to have just a fence around it and a low level security. You don't need guards protecting it. It's not something you'd want to put in your cereal bowl, but it's also not something that is of any great risk of bad actors aren't going to do anything with it. So that is still stored as a somewhat toxic waste product that we don't have a great use for now though it could be used. So that's an important thing to keep in mind that that large part of it is mostly uranium 238 and zirconium.

(01:31:54):

That uranium 238 could be used to down blend. Say if people are decommissioning nuclear warheads as they did through the megatons to megawatts project back in the eighties and nineties, you have that very high level enriched fuel or weapons grade material and you need to down blend it. So you use depleted uranium, uranium 238 for the down blending to make mox or mixed oxide fuel. So it is useful. Or you could put it into a breeder reactor and you could, with a breeding ratio of greater than one, you'd end up turning it into plutonium and make it into fuel for a waste burning reactor. So that's also a possibility, but it doesn't require a deep geological repository. It doesn't require high security. Then there's the half percent that goes in the waste burning reactor. What happens with that? So it is a continuous closed loop fuel cycle.

(01:32:52):

It goes through a bundle goes in and a bundle comes out about once a week and the ones that are removed go back into the recycling plant, the short-lived fission products that still need disposal, those are taken out because they dampen the chain reaction. The fuel is topped up with a fresh recycled fuel from a conventional reactor and it goes back in at the end of useful life, you still have the seven ton core that you started with. So 60 years later you still have seven tons of that material that would be high level waste. The rest of it is mostly consumed matter to energy in the operation of the reactor and you get some of that, the short-lived high level waste out. It is in a different form. So we're working with Canada's nuclear waste management organization, the NWMO, on acceptance criteria for the material itself and the containment of it to go in their deep geological repository. The drawback there is one drawback when you start out with used fuel, it's in uranium oxide form, it's not water soluble. The little bit that we end up with that's still high level waste is water soluble. It's an assault form, so it needs more careful containment and you need to have some sacrificial metals inside the containment to prevent oxidation. It does require different handling, but there's a lot less of it.

Hon Dick Barry (01:34:30):

More information than we need.

Rep. Keith Ammon (01:34:31):

I think it's very interesting. Christian, thank you very much. We're going to have to end it there and to know that you are in a neighboring state currently. Maybe we'll run into you sometime.

Tristan Jackson, Moltex (01:34:46):

I hope so.

Rep. Keith Ammon (01:34:48):

(Does he give tours?) Doug Thomas wants it off. You give tours.

Tristan Jackson, Moltex (01:34:55):

Well, there's not a lot to tour right now, so we do have stakes in the ground where that first of a kind is planned to be built. We've cleared the site. You could take a look at Point LA Pro Nuclear Power Station and at our site where we're doing some geotech studies, but there's the facility itself is still on the drawing board. It's planned to be operational in 2031.

Rep. Keith Ammon (01:35:18):

Okay, thank you.

Rep. Michael Harrington (01:35:18):

Do you have a contract with anybody, signed?

Tristan Jackson, Moltex (01:35:22):

Contracts with NB Power as the site and the offtaker? Yes. And with supply chain partners, project delivery partners, yes. Is that what you're referring to? That kind of contract?

Rep Doug Thomas (01:35:40):

Thank you. I only asked because I am going to be up in St. John in two weeks. That's why I was asking.

Tristan Jackson, Moltex (01:35:46):

You'd be more than welcome to come by company headquarters, meet our CEO, Rory O'Sullivan is there and any of the rest of the team that's around at the time.

Rep. Keith Ammon (01:35:56):

Great. And we have your contact info. Tristan, thank you very much and you're welcome to stick around.

Tristan Jackson, Moltex (01:36:01):

Please do if you have further questions, send me a note anytime. I'm happy to. And apologies. I'm sure I gave as was mentioned, too long answers on some of those, but if you do have follow-ups, I'll hand back the mic, but feel free to be in touch by email.

Rep. Keith Ammon (01:36:16):

Great, thank you very much and I enjoyed all the information. Good stuff.

(01:36:20):

We'll go on now to Gus from Ultra Safe Nuclear and Tristan, you're welcome to stick around if you'd like or drop off whatever you prefer. This meeting will probably go a little long and Gus, it's up to your timeframe. We normally end at the two hour mark, but I think we may go a little bit long so hopefully everyone can stick around. Gus, take it away. Thank you for joining us.

Donald "Gus" Gustavson, Ultra Safe Nuclear (01:36:45):

Absolutely. Good morning folks. Sincere thanks to all of you, Representative Ammon and the rest of the commission for allowing me to speak today. Unlike Tristan, I do have a slideshow. I will ramble too much and go off on too many tangents unless I kind of keep myself on the study and narrow. So before I dive in a little bit about myself, my name is Donald Gustavson or go by Gus. I'm the business operations manager for our fuels division. So fuel is a much more critical part of the advanced reactor fleet as Tristan kind of mentioned. And so I worked there. That's my expertise. I've been at USNC for about two years. Prior to that I was in kind of the strategy consulting world for another two years. Before that, I was a chemical engineer and I worked in oil and gas as a matter of fact in Houston for four years.

(01:37:37):

And then earlier that I was an army officer for five years and as a matter of fact, as a strategy consultant, we're paid to sound smart, maybe not deliver, but it was during that work and specifically a lot of projections on energy sources and uses in the 2030, 2040, 2050, et cetera timeframe that I became convinced that nuclear energy was an imperative if we were to meet any sort of realistic carbon reduction goals. So that's what prompted my shift in industry and I think I heard some similar sentiment from folks on the call today and that realization. So what I like to talk about, so I will kind of cover who USNC is and our product micro module react in the beginning. But when Representative Ammon reached out, he said, really interested in hearing about our nuclear fuel manufacturing with Framatome. So I proposed to kind of quickly move through the USNC reactor part and talk about the fuel. And for advanced reactors, fuel is a critical part of it and it's, I think the nuances of that value chain are often overlooked. Tristan mentioned HALEU, HALEU underpins a lot of it and there's a lot of TBDs out there in the HALEU world. So we can talk a little bit about that and maybe you guys get a little new perspective and then yeah, just continuous with the other groups. Please just say, Hey, if you have a quick question or something like that during the meeting, I won't be paying close attention to the screen.

(01:39:18):

So USNC has an overall mission of providing carbon free power for our space and commercial applications. However you look on the right side, there's three products there, really cool sexy space applications? That's essentially a different division, the USNC tech division, and they work on government grants and NASA grants and they're part of what we do. And on the USNC proper side, we provide support to them, we make fuel for them. But really most of what I'm going to discuss with you guys today and what 95% of effort is focused on is the micro modular reactor (MMR). That's our commercial land-based application.

(01:40:01):

It does have shared design and fabrication resources, specifically the fuel forms, particle based fuel forms, TRISO, although different types of TRISO depending if it's space or commercial. What is the MMR? The micro modular reactor, we like to term it is a nuclear battery. It has variable power and that power is inversely related to the lifetime of the fuel based on how hard you run it. It could be one to 15 megawatt electric again based on the demand you put on it or 10 to 45 megawatt thermal and say 40 year lifetime. So this is probably a good time. I didn't have a slide dedicated to it, but since you asked Tristan what is our LCOE? In a micro modular reactor, a lot of these new advanced reactors are micro modular, they're small modular, they're modular reactors and the modular term denotes that the construction will be a higher proportion of it will be not at the reactor site, it'll be in other locations and there'll be more of an assembly process at the reactor site.

(01:41:08):

And a lot of that is because of really the fuel forms which take much more of the safety burden. So you don't need a massive concrete vessel and all these other things and other aspects as well. But that's the modular portion of it. And so there's always first of a kind, next of a kind when you talk about these module reactors because they're learning curve, I guess there's learning curve for the more standard fleet of reactors, but we say 12 cents per kilowatt hour, first of a kind and 8 cents and below for next of a kind. That's what we say and our primary customer base is right now where we're very, very hard in the money is much more remote applications. These are our primary customers. You'll see we have two public projects that are demonstration test reactors that we're working hard on delivering on, but our primary customers are remote industrial, remote communities and then we're starting to become more attractive in some other locations with even more in the grid aspects. So that's the MMR, the micro module reactor and give a quick rundown is what its main working components are and how the fuel relates to it. So the bottom right is the reactor itself, it's about a football field in terms of the footprint, it's much smaller than the Moltex reactor that our friend Tristan was discussing in terms of total output. So it's a smaller reactor, so his is like 600 megawatt and this is much smaller.

(01:42:54):

The one key aspect of this, we really want to have a very strict division between the nuclear side of the plant and the power production side of the plant. The power production side in this case is a molten salt storage tank. It's very similar. It's copied from what large scale industrial solar farms use. So the reactor has a primary power loop secondary exchanger to the molten salt and it stores the power in a tank to be used as needed. Then middle bottom is the reactor side itself, and then bottom left is the fuel core. This is an array of graphite blocks and the graphite blocks, if you look in the upper right have channels. So these are nuclear grade machine graphite blocks and they have channels and in those channels are stacked our proprietary fuel form, which is, it's called FCM fuel, fully ceramic micro encapsulated.

(01:44:00):

And it's a silicon and carbide pellet filled with TRISO particles, something Tristan mentioned, TRISO is a fuel form that a lot of the advanced reactors in development you'll see X-energy, Kairos, they're using TRISO and TRISO is a form. I guess I can just move on here. So TROSO is fuel form is actually developed in the sixties. It's very old. It has a wealth of radiation and technical data underpinning it, which is one reason why it's used. And TRISO fuel is a kernel of uranium. It's called UCO. It's actually a heterogeneous mix of uranium carbide and uranium oxide and it's coated in layers of carbon and silicon carbide to retain fission products. So it's by itself a very robust fuel form that can withstand all sorts of reactor operating conditions and stay very stable and safe. And then our kind of difference in the fuel is embedding it in a silicon carbide matrix and well, we can discuss the details if you're curious, but this is a manufacturing process made possible by 3D printing added manufacturing and some advanced manufacturing techniques, just chemical vapor infiltration.

(01:45:20):

So we have silicon carbide cups that are filled with TRISO particles and surrogate silicon carbide and we densify that via chemical vapor infiltration. You have a very dense silicon carbide is a ceramic that's extremely stable and all the reactor conditions you could imagine, it just smiles and is happy. So that's an inherent ultra safe. Our name is very on the nose. The idea is worst case scenario for a reactor control rods are pulled out and it's completely just run unchecked. The fuel form, it just stays robust and so it dissipates heat and it dissipates heat over years or something. But so the worst case scenario is there's no meltdown, nothing melts, it's just an economic issue. And then so our fuel manufacturing today, this is kind of diving more into the fuel side. We have a pilot fuel manufacturing facility in Oak Ridge, Tennessee. That's typically where I sit.

(01:46:23):

I have two of my three kids have the flu now. So I'm at home trying to pull my weight here. But so we have our pilot fuel manufacturing facility and we're making TRISO fuel today and we say it's really the only private TRISO production facility in the western hemisphere. They make it at commercial scales in China where they have reactors there. And critically we make fuel using the same scale production equipment we use in a big factory. The key difference being in a big factory, you would just multiply it. So instead of one furnace you would have five or 10. And that's kind of just based on these production processes that don't really scale in that way because you're doing 3D coding methods that don't really scale, they're not tuned to scaling. So it's important for us because it really strengthens our licensing basis and all these other things that we're doing it the same exact way just at 1X rather than 5X.

(01:47:27):

So this is kind of an overview of the manufacturing process, but essentially, yeah, we print silicon carbide shells and it's a very flexible kind of production process. So do all sorts of different geometries. You see some cool ones there for some of our space projects, but they're printed, they're filled with SiC powder and fuel, SiC powder and TRISO, and then they're further densified in another run in our chemical vapor infiltration furnace. So these are some pictures of the inside facility, again just 20 minutes away from me now in Oak Ridge. And then this is kind of an overview of all the people we have all over the world, Oak Ridge, two green dots are our fuel operations. We also have additional non radiological additive manufacturing facilities in Salt Lake City. It always makes sense if you can to split the radiological and non-radiological parts of your business just because of the additional burden that comes with operating nuclear facility.

(01:48:34):

And then we have some also key are again, UIUC (University of Illinois Urbana-Champaign) and Chalk River. Those are two public projects. Those are projects that we're just laser focused on delivering on. Tristan also mentioned the DOE being a strong supporter of advanced nuclear. And I think that's really true. If you listen to a lot of their communications though, like Jigar Shah and all that. One thing they've stressed again is they want to see signed orders from customers and what gets signed order from customers if you deliver on your first projects. I mean the very fair criticism of nuclear in the US is that we haven't delivered well on projects and I think one micro modular, the modular reactors part of our to be delivered on value proposition, that delivery risk is lower based on the modular nature of the design. You have less of a, it's not a huge massive enterprise.

(01:49:35):

It's not as much of a mega project as a smaller measured project. It's more attractive to... ISO, Eric mentioned, Hey, what do we judge? We judge reliability of the asset. Well tell you, those developers are also looking at the business economics and again, a huge nuclear project, those economics, that huge CapEx, if it fails you go bankrupt. So having a smaller projects that aren't existential threats to utilities is also a big part of it. But most important for us is we deliver on these first projects and then that really provides inroads and we have our other customer pipeline of commercial projects and in development too. So yeah, I'll pause there before moving on to some more nuanced discussion on the fuel side. But please, what do y'all got?

Rep. Keith Ammon (01:50:28):

Yeah, we have a question in the room.

Rep. Michael Harrington (01:50:30):

Yeah, actually I have about a thousand questions, but I'll try to more of a practical matter, as you may or may not be aware, in New England where we have merchant plants, there are no vertically integrated utilities here. So we know there's some activity in other parts of the country, but it almost exclusively has to do with vertically regulated utilities that can put their customers on the hook for the cost. And as we've seen down in Georgia, sometimes that can be very, very expensive. So can you imagine that anyone would be willing to invest their own money in a nuclear facility in let alone New Hampshire, say New England, or it would have to be built multiple ones, be built someplace else in a vertically regulated utility system and built on time and on budget first.

Donald "Gus" Gustavson, Ultra Safe Nuclear (01:51:23):

I'm certainly not an expert on the New England utilities. I'm actually Connecticut native, but I've not been there for a long time with the TVA here. And I imagine the latter. I imagine the latter is that there's got to be successful demonstration of projects on time and on budget before people are willing to pony up money. And then you can have developers develop them and then have some reasonable assuredness of cost.

Rep. Michael Harrington (01:51:51):

You've talked a lot about the fuel, but is this HALEU or is it four or 5% enriched? What's the

Donald "Gus" Gustavson, Ultra Safe Nuclear (01:51:58):

Yeah, so I had those in previous slides. So we have flexibility in our fuel. Our initial offerings are for less than 10% so-called LEU plus. And you say less than 10% just because every fuel have to say less than because of you can't go over based on your licensing, so it's going to be like 9.75, but we can be flexible for HALEU too. And HALEU is better economics

Rep. Keith Ammon (01:52:27):

And the size of your plants are, it's a micro in scale. Could you talk a little bit about potential customers? Would they be like an industrial power zone or like an industrial, some kind of industrial customer?

Donald "Gus" Gustavson, Ultra Safe Nuclear (01:52:43):

So yeah, industrial remote mining communities are one, server farms are another one because of their requirements for capacity factor and losing power is catastrophic for them and many of them are also in remote locations. And the T&D demands are very large. Remote communities. A lot of our very advanced talks with folks in Canada and Alaska. So those are some examples of our initial ones.

Rep. Keith Ammon (01:53:18):

Your fuel production, is it just for your design or can the other manufacturers utilize it?

Donald "Gus" Gustavson, Ultra Safe Nuclear (01:53:25):

Yeah, I'll get into that too. So we are vertically integrated. That's a big strategic decision underpinning a lot of our actions. So we're bringing our production online and it's tailored for our proprietary FCM, but an input into FCM roughly 60%, 70% of the time and money required to produce it is in making TRISO and TRISO is used in a lot of other advanced reactors. That's certainly an attractive business case for us. You can look across the other advanced record developers and a lot of 'em may or may not, in our opinion, be giving fuel production the right amount of respect and focus at this time. So we'll see how that works out.

(01:54:19):

But that's a good segue, let me jump in there and there'll be more stuff in the fuel where I wanted to focus my time. And I have some slides that I think might elicit more conversation along those lines. So the bottom line here is what's written on the bottom. So advanced reactors, which doesn't have a strict definition, you can hear it used different ways. Tristan mentioned generation IV reactors of which the MMR is, there's a lot of terms out there, but the main takeaway is the fuel forms that underpin them - a lot of them, not all of them, they require... An LWBR/PWBR reactor today, fuel is like 2% of the opex, roughly 2 to 4%. For advanced reactors it's often like 20 or more percent, 20 to 30% of the opex because you use, there's a lot of effort in making that TRISO.

(01:55:17):

So instead of just centering uranium oxide into pellets and putting in cladding and the reactor, you have very advanced manufacturing techniques coating them in silicon carbide in a robust ceramics. So that's why fuel is a much more important part of the discussion. And forgive me for any of you folks, this is kind of well understood to you, but it's kind of helpful anchor to say if you want to put fuel in a reactor, you have to think about the whole value chain. And a lot of it often isn't appreciated and a lot of it isn't done in the US of course. You've got mining and milling, in situ leaching or open pit extraction and either way uranium oxide is pulled out from rock and then you have conversion where that oxide is transferred into uranium hexa fluoride. And that's just so that it can be enriched. Uranium hexafluoride, it vaporizes at higher temperatures and then it can, under gaseous centrifuges, use it to pull out the heavier isotope, the non-radioactive isotope U238, leaving behind the radioactive isotope U235, and then before it is used to fabricate fuel that enriched uranium hexafluoride must be deconverted back into the oxide form.

(01:56:48):

And then so you have uranium dioxide oxide and it's fabricated into fuel, fuel fabrication facility. And that is you take the fuel, you center it into a ceramic pellet and that's pushed into a metal cladding, typically zirconium alloy and then it's load into active core and that's Seabrook, New Hampshire there. So that's kind of the basic parts of the fuel cycle. And if you look at where we are today, what happens where, it's interesting to know very little mining in the us, you've got some very productive world-class mines in Canada. Conversion there is... Interestingly, because Tristan, Tristan mentioned Canada a lot and we have a couple projects there, there's not really any conversion enrichment in Canada. They don't need to. They use natural U so they don't need to convert and enrich it and all have all that capex associated with it. The economics the reactor are different. But that's one kind of cool differentiator.

(01:57:48):

There's a big conversion plant in Metropolis, Illinois that's been inactive. It's supposed to come online this year or maybe it already has, but I don't think so. I was trying to research it this morning. It's difficult to tell. We have one enrichment facility in Eunice, New Mexico, and that's in operation today. It supplies maybe 20% of our domestic need. I was just actually at our fuel fabrication partner, Framatome, last week and you could see all of their incoming fuel they used to fabricate. And about 20% comes from Russia, about 20 to 30% comes from other locations in Europe. And then you've got some from Eunice, New Mexico, some various other sources too. And then fabrication, we have three nuclear fuel fabrication facilities in the US that provide most of the fuel for our fleet. One in Richland, Washington, that's Framatome. There's one in Wilmington, North Carolina, that's GE. And then there's one in Columbia, South Carolina that's Westinghouse.

(01:58:51):

So you've got.. And deconversion typically happens at the fuel fabricator, at least in the us. So that's kind of the slate of what we have in the US today. So we typically import most of our uranium as enriched uranium hexafluoride at like a 30B container. And so that's most of our fuel is imported as UF6. So that's what we have today. And then when you want to deploy this fleet of advanced reactors, what are the implications for where we are today, what we need to get to? So there's two big needs. There's higher enrichment. Most advanced reactors use HALEU. Our design is using less than 10% for the initial projects, and then there's actually scaling the production equipment needed to produce those advanced fuel forms. So it's a different process than typical PWBR and LWBR fuel bundle manufacturing.

(01:59:56):

So there's the ladder, the production equipment, that's a engineering problem, that's how do you scale it efficiently and well. And that in the higher enrichment are both licensing issues. If you are a facility that handles special nuclear material in the front of the fuel cycle, you require a part 70 license from the NRC. So that license gives you the right to handle fuel based on the activities in that license. So it has an enrichment part of it. So if you want to increase the enrichment of your facility, you need to submit a license that's going to be, depending on the complexity, 18 months to three years, you get to submit a license. And if it's a new facility, it'll be much longer and I'll kind of get into that. And then you have to have that license either created or amended for the new activities.

(02:00:50):

So if you're doing new process, for example, making TRISO relative, then you also need to submit a new license. So there's this regime we have now where there's going to be a lot of new licenses issued from the NRC and there's going to need to be deployment of new capabilities. So those are the two key things. So as far as what the fuel cycle looks like, mining and milling, conversion, there's no change today. I mean there's no enriched fuel being used there. There's no change. Enrichment? I think back in the early days, or not the early days, but a couple years ago, everyone's idea was that we would get our HALEU from Russia where they produce it today and they enrich it today, but that's off the table now. We still get a lot of our other enriched fuel from Russia, but that's been grandfathered in because of these long-term off date contracts. I see a chat here. Did someone ask a question?

Rep. Keith Ammon (02:01:51):

I think Tristan added a footnote to one of your comments.

(02:01:53):

[Tristan wrote: FYI on Canada not needing to enrich fuel, that is correct because all of Canada's 19 operating reactors are CANDU technology which uses natural (un-enriched) uranium. However, Canada is now building a BWRX-300 light water reactor from GE-Hitachi, which will require enriched fuel, and has plans to build several more of those units. Even then, Canada has no plans to enrich fuel, but with the BWRX-300s coming online, Canada will for the first time have fuel supply dependence on other nations for enriched fuel (hopefully that will come from the US, but the US needs to ramp up enrichment capacity).]

Donald "Gus" Gustavson, Ultra Safe Nuclear (02:01:54):

Oh, nice. Okay then yeah. But we were talking about HALEU in Richmond in the US there's no capacity today. Urenco is the one facility that exists today and they think they can bring capacity along by 2029. That's a mix of having to get new equipment and having to amend their license for higher enrichments. I also should have mentioned that less than 20% or above 10% restrain is no longer a category three license. It's a category two license from the NRC, which has some additional safety and tracking burden. So there's some more that goes into it. Centrus has a facility in Piketon, Ohio that recently came online. I think it's like a 900 KgU per year of enrichment capability for which is a good nice little milestone. But if you look at this then there's nothing else we can do with it.

(02:02:52):

There's no commercial facility in the US that is licensed to deconvert UF6. Framatome who we're partnering with to manufacture fuel. They will also deconvert the fuel, but they have to submit a license amendment and get new equipment. They need to keep those two facilities distinctly siloed to satisfy the NRC. So there's going to be, there's a lot that goes into the whole fuel cycle. And when people talk about enrichment is the bottleneck, that's true, but then you have the rest to think about and fabrication where I'm laser focused on.

Rep. Keith Ammon (02:03:29):

Sorry to interrupt. We have a question from my Carrington in the room.

Donald "Gus" Gustavson, Ultra Safe Nuclear (02:03:32):

Okay,

Rep. Michael Harrington (02:03:33):

Yeah, as far as the HALEU goes, I mean it seems like it's a chicken and egg situation, just your opinion. It seems to me as if that's going to operate, it's probably going to end up with the federal government contracting for a certain amount of HALEU and then selling that back to people who then say, well, I'll build a reactor that uses HALEU, now that there's a source. Do you see any other path to get there or is that what's going to happen?

Donald "Gus" Gustavson, Ultra Safe Nuclear (02:04:00):

That's probably what's going to have to happen. That's been their position, or at least they're doing RFPs for HALEU production, meaning soliciting HALEU requirements for the next 10 years, who would be willing to be like customers. And again, the government would buy it at some guaranteed thing that's been their position. Until it comes to fruition, who knows? But that's the most likely course of action in my opinion.

Rep. Michael Harrington (02:04:22):

Thank you.

Donald "Gus" Gustavson, Ultra Safe Nuclear (02:04:27):

Yep. Then the final kind of step is fabrication. You need a licensed fuel fabrication facility today. There's no commercial fuel fabrication facilities licensed for above 8%, 6.5 to 8%. These are things that people don't always publicly discuss, so it's not completely clear. And then there's no commercial deployment of production capabilities for TRISO advanced fuel forms. We have our pilot facility in Tennessee, but that's really it. They make it in Oak Ridge National Laboratory and they're talking about making some in, Oak Ridge, much smaller scales in Los Alamos as well. But those are TBD and the Oak Ridge one is shutting down apparently.

(02:05:12):

So I want to talk about our approach USNC's approach to tackling this kind of piece. So Urenco is the one fuel enricher in the United States. They feel very confident that they'll be able to do LEU plus by the first half of 2025 and they have a siloed already portion their production capacity and they're amending the license for it. So that's again, our reactor design is flexible based on enrichment and less than 10% is not as great economics as HALEU, but it's still completely viable and relatively efficient. So we've signed a contract with Urenco that's public for our initial production requirements to be delivered in that time. So for them they require the enrichment and again, the mining and milling conversion, they'll procure that as they do with everything now. Framatome, we have partnered with Framatome. Framatome is one of the three fuel fuel fabricators in the US.

(02:06:27):

So we have a joint venture. We're forming a joint venture partnership with them. That's public. It's been public for a while and there's a few reasons why this is, we think a very prudent decision relative to other options out there like a greenfield. So it accelerates our timeline of first product by using a site under active NRC license. They will have to do a license amendment for a higher enrichment. So they'll have to amend their existing license for our new activities and for a higher enrichment. So they'll be justifying why they can keep that high enrichment very separate from the rest of their facilities. And that's a much bigger lift than a greenfield activity. We have to do a new license submittal. There hasn't been one, I think one of our, X-energy is doing for their TRISO production facility, US and Oak Ridge, but that hasn't been done for decades.

(02:07:26):

You've got to do massive environmental impact statement. It's a much more burdensome thing. So we thought that was too much execution risk relative to what we wanted to deliver in the commercial pipeline. One, it brings invaluable expertise from people who have done this at scale for a long time. So we have the technological expertise and in making this stuff. They have the expertise in doing it at commercial scale, commercial scale quantities. Critically, it provides nextdoor deconversion capabilities, which are an important part of the value chain that people forget. And it comes with the very kind of not visible infrastructure that's super valuable. They have a mature material control and accountability program. They have all sorts of, have all the quality regime that for really commercial grade production that you need. And then finally for a joint venture, why that we think that's always good in these sort of new technology commercialization type of situations where you have the sharing of upside and downside and it'll kind of mutually incentivize us both to do things on time.

(02:08:50):

And finally, one other additional piece of this that people don't always think about, you've got to move this stuff around, you've got to move the fuel around, you've got to move the uranium around. When it comes to moving enriched uranium hexafluoride, it is called a 30B today. But that's not, I think a big risk. And most of the people who do this today, which is Urenco and Orano, they have their own separate projects to have licensed containers for this approved by the NRC pretty soon. These are not huge modifications. These use existing design. One is a more spaced out array of the tubes that hold the uranium hexafluoride. And then the other I think has some poisons in it. And then finally you need a licensed container from the NRC to for whatever your fuel form is that you'd like to ship.

(02:09:48):

Now these shipping containers, there's all sorts of different types out there. So depending on your mass of U235, you can use an existing container, but that'll be a small quantity. So we're licensing one for our own graphite block loaded with FCM. That's going to be what gets shipped. It's a modified design of existing license package and we're manufacturing prototypes now. And then that package has got to be tested at a testing site and then licensed via NRC. So I kind of went a lot through that. Not too many questions for the fuel side, but what do you guys got? I mean these are the things that I think maybe aren't always paid, but outside of HALEU, which you mentioned the fuel isn't always talked about as much.

Rep. Keith Ammon (02:10:39):

Yeah, I mean that was a lot of more detail I think than we've gotten from a lot of our other presenters on the fuel side, the fact that your TRISO is another step further past the LEU plus and the HALEU. Any other questions for Gus and anybody online? Raise your hand if you have a question. And Gus, would you be willing to share that slide presentation with me? I'll reach out to you afterwards because I'd like to go back through it again myself and read some of the fine print.

Donald "Gus" Gustavson, Ultra Safe Nuclear (02:11:21):

Absolutely. Yeah, I just don't think it's widely appreciated. The fact which you have these licensed facilities and the runway for that licensing to handle all the front end of the fuel cycle. So I mean it is well understood, at least often talked about, hey, if you're going to have an operated reactor that needs a part 50 or part 52 license from the NRC for the reactor to operate, but there's all these other licensing concerns for the fuel side that are often overlooked. And we're going through that now.

Rep. Keith Ammon (02:11:53):

Yeah, I think the commission has a basic understanding that the fuel supply chain is still being built out and that's part of the possible constraint to full scale commercialization. So the fact that your company's focusing on it is very interesting. Alright, thank you Gus. We really appreciate it and thanks for hanging in. Absolutely. We had some glitches.

Donald "Gus" Gustavson, Ultra Safe Nuclear (02:12:20):

Please with any questions. I think you guys have my contact info, so happy to discuss further.

Rep. Keith Ammon (02:12:25):

Yeah, excellent. And we have some members in the room that are on our house science and energy committee, so these issues come up quite frequently I think. Cool. Alright. We have maybe five minutes of additional commission business that we'll try to get through quickly. And you're welcome to drop off if you'd like or stick around either way. But thanks for your time. I hope your kids feel better. Yeah,

Tristan Jackson, Moltex (02:12:49):

Thank you all. It was good meeting you.

Rep. Keith Ammon (02:12:51):

Thank sticking around you too. Alright, I just want to wrap up our minutes. I think we have six of us in the room. I sent these out a few days ago. There was one change that I'd like to point out. I should have underlined it so I could find it quickly. It was the Zap Energy folks, I should have page numbers on this. It's the fourth page of the minutes and it's before the Q&A section. It is a bullet point that begins With regarding the development's timeline. The last sentence in that bullet, the plant would demonstrate the reactor at scale and make electricity available to the grid. I think the way that the minutes were generated, it said provide electricity to the grid. So he wanted to make sure that they're not providing it unless they're asked to provide it. So they're going to make it available. Just a very fine change in the words. And I'll accept the motion if everybody's comfortable to approve the minutes.

Marc Brown (02:14:05):

Motion to accept the Minutes.

Bart Fromuth (02:14:06):

Seconded.

Rep. Keith Ammon (02:14:07):

Alright, Marc Brown made the motion. Bart Fromuth seconded. All in favor say aye. Aye. Aye. I don't think we have anybody online, commission member. Yeah, and any opposed? Okay, so that was unanimous. I'm just going to say the names for the minutes. Cathy Beahm, Marc Brown, Bart Fromuth, Matt Levander, Michael Harrington and myself. And that was unanimous. Alright, I'm trying to hurry. I apologize for going long. Thank you for everyone sticking around. Old business. We had some correspondence. Oh our previous speaker and that was Ryan Duncan of Last Energy. He answered a question that he wasn't able to answer. I think I forwarded that to you and if I did not, I'll soon do that and I'll follow up with that if I haven't already. I just can't remember if I sent it to you, but he was kind enough to follow up on a question. And let's see, I want to talk about the final meeting. It's scheduled for November the sixth here in this room. I have yet to confirm some speakers. I have lots of invitations out and I'll try not to book more than two for that meeting. So we have a little more time to discuss. Marc, do you still

Marc Brown (02:15:32):

Do you want me to try to get New Core to talk about their MLU with NuScale?

Rep. Keith Ammon (02:15:38):

If you can be certain that we can get that done. I just can't push it to the last minute cause then I stress out.

Marc Brown (02:15:43):

I understand. I'll let you know within the

Rep. Keith Ammon (02:15:45):

Week. Okay, within the week.

(02:15:49):

Michael Vose sent me a link to a webinar that was put on, I'll just pull it up here so you can see it. And they were talking about fuel recycling. It's actually on, let's just way to get to it. So there's a Twitter feed that some of the information goes out about this commission and things that we're focused on. I can send you the link or you can go look for the Twitter feed. It was a webinar on fuel recycling and there's a video if you'd like to watch it. [https://centerforsecuritypolicy.org/webinar-clean-energy-is-a-terrible-thing-to-waste/]

(02:16:40):

But what I learned from listening to that webinar is there is $10 trillion roughly of, they call it "slightly used nuclear fuel" all around the country. And they can reprocess it for at least the next 30 years into fuel for some of these advanced reactors. So I may try to reach out to one or two of the speakers on that webinar because I think they'd be interested in talking to us. They were aware of our commission and mentioned it in the meeting. So that's kind of interesting. We're getting

Rep. Michael Harrington (02:17:11):

Just one thing on that. This isn't anything new. Processing and looking at it then every time it's been approached, it's been brought up and then decided, nevermind, it's just too expensive to get the fuel and enrich it. It's cheaper than trying to reprocess it. Plus you get the proliferation problem because you're chemically extracting U239, which is what you make bombs out of. And that becomes independent of the rest of the material, at least for some part of the process. So that becomes a big issue. And it was looked up before and we were going to have the Clinch River fast breeder reactor that they spent, I don't know, a couple of billion dollars on. Jimmy Carter canceled that. So I would take a grain of salt with anything on reprocessing, just simply because as of right now, everyone talks about spent fuel. But I mean if you go to Seabrook, what do you have a couple of acres taking up. But it's not even the actual things themselves could fit in this room. And that's gone on for years. So I mean, it's not a pressing point that I think people are getting at unless something really changes. We're not getting the fuel from Russia. And of course now Biden's closed off a good portion of the sources of uranium in the United States to mining. So of course that could be unchanged by a future president. But I just see right now I'm kind of skeptical.

Rep. Keith Ammon (02:18:35):

I think technology may catch up at some point, but maybe we're not there yet. Mic, it's right there in front of you.

Hon. Dick Barry (02:18:42):

I'm just a little concerned that our friends that ISO New England have them gone out and actively solicited input from the nuclear community to give us a proposal for forward looking opportunities here. And maybe something from this committee to send, we would like you to look some more nuclear and how it's help us help you kind of a thing.

Rep. Keith Ammon (02:19:09):

That's a good idea.

Hon Dick Barry (02:19:10):

I was really disappointed.

Rep. Michael Harrington (02:19:11):

They're going to say that they're fuel neutral.

Hon Dick Barry (02:19:12):

But I'm disappointed they didn't.

Rep. Michael Harrington (02:19:14):

That's what they've pushed. But I mean if you talk to 'em, not in public, shall we say, you sometimes get a little different, more realistic approach to what's going on. This idea that we're going to have 20 gigawatts of offshore wind and then we're going to live happily ever after. They know isn't going to work, But because of Massachusetts, Connecticut, Rhode Island, they're almost forced into taking that position even though they,

Hon Dick Barry (02:19:37):

Maybe we can force them to look at nuclear by just saying, alright, we talk more about that check off line. Alright, so the next meeting, it'll be our final meeting, November the sixth. And there may be an issue with the facility. We're not quite sure yet. I think so. There's a chance. It may be online, but hopefully we can meet.

Cathy Beahm (02:20:01):

I'll know.

Rep. Keith Ammon (02:20:02):

Yeah,

Rep. Michael Harrington (02:20:04):

Tell them we want the room and that's it.

Rep. Keith Ammon (02:20:05):

Yeah. Well

Cathy Beahm (02:20:06):

It's not in the room, there will be no air.

Rep. Keith Ammon (02:20:08):

There's some maintenance that may or may not be happening here, but we'll find out and we'll let you know.

Rep. Michael Harrington (02:20:15):

Hey, one thing I just wanted to mention, if This's particular thing that people have interest in a particular topic, send me an email because I have access to the American Nuclear Society database, which is monstrous and includes every issue of nuclear news for the last 50 years. So if you have a particular topic that you want some more information on, I can get in to get it. I'll set it to keep these discriminating. So just something, think about the other thing about, I haven't seen it yet, but I didn't see a seminar on Oppenheimer that was put on by Los Alamos and they say it's almost a hundred percent accurate. What? Its with a couple of exceptions. [https://www.ans.org/webinars/view-opp2023/]

Rep. Keith Ammon (02:20:55):

I may have seen that they had interviews with people talking about lab.

Rep. Michael Harrington (02:21:01):

Yeah, it was a Zoom thing from Los Alamos.

Rep. Keith Ammon (02:21:03):

Yeah, I saw that it was pretty good. Pretty good.

Rep Doug Thomas (02:21:06):

When you say final meeting season or this commission ends, thank god, December 1st. We're supposed to have our final report self inflicted billing statements at all. No, no, Rep. Michael Harrington (02:21:24):

No. You'd have to get new legislation. Yeah,

Rep. Keith Ammon (02:21:27):

You could have your own. So I put in a bill and I'm hoping to talk to David. I think he dropped. So in our RSAs, we talked about this before. There's in the atomic energy, there were supposed to be studies being done regularly that just have kind of fallen off the map. So I put in an update to that bill to put, they have to be done, I think I said every four years just as a stopping point. And so that'll kind of be, and I also added advanced nuclear. There is a federal definition for advanced nuclear. So I pointed the RSA to that and I said that the Department of Energy would be responsible for doing studies on advanced nuclear every so often. That's just my initial bill. I'm just starting the conversation. But that's where I would've to go. This kind of resurrect some of these old statutes.

Rep Doug Thomas (02:22:22):

Is that an amendment you put forward?

Rep. Keith Ammon (02:22:26):

I filed a bill that,

Rep Doug Thomas (02:22:30):

But you're filing, you submitted under amendment our

Rep. Keith Ammon (02:22:40):

That's for the microgrid bill.

Rep. Michael Harrington (02:22:42):

Yeah. When is that coming? I was supposed to remind you about that.

Rep Doug Thomas (02:22:44):

Yeah, because that's cause our

Rep. Keith Ammon (02:22:47):

Let's talk about that because it's not really a commission. I mean it's somewhat related, but if you stick around a minute, I'll give you an update on that.

Rep. Michael Harrington (02:22:54):

The other thing I wanted to say is that,

Rep. Keith Ammon (02:22:57):

Yeah, I'll be in touch with you.

Rep. Michael Harrington (02:22:59):

There's lots of activity going on across the country. There are all sorts of states that flipped their laws where they said no new nuclear plants now they will have nuclear plants. And I think if you've heard the guy speaking about Germany, I think people that don't have green colored glasses on, I guess I should say, are looking ahead and saying, we just can't get there on this without nuclear, it's impossible.

Rep. Keith Ammon (02:23:23):

Sometimes your energy policy exists so that other people can learn from your mistakes, right? Yeah.

Rep. Michael Harrington (02:23:28):

That's what Germany is doing.

Rep. Keith Ammon (02:23:29):

Alright. Motion to adjourn.

Rep. Michael Harrington (02:23:31):

Motion.

Rep. Keith Ammon (02:23:31):

Alright. All in favor say Aye. Any opposed? Thank you everyone.

Rep. Michael Harrington (02:23:37):

Yeah, we wanted to remind you about that amendment.

Hon. Dick Barry (02:23:41):

Keith, thank you. A lot of work.