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

Good morning everybody. This is Representative Keith Amman in Concord, New Hampshire, and we're calling the meeting of the Advanced Nuclear Study Commission to order. It is 9:03 in the morning and we have some commission members and guests in the room and I see our three speakers are online and some other members of the public. So I posted a link to the chat with the current agenda that we'll be going through for those online. And then we have printouts in the room based on the same webpage. Alright, so we will go right into our presentations. The first one is kind of a, I'd call it a pallet cleanser. It's a little different than what we've been hearing and Ryan McLeod is he works for the Canadian Nuclear Laboratories and he recently won an award for suggesting a novel solution for nuclear and he'll tell us about that and also more details about that proposal. And Ryan, I see you online, are you able to speak?

Ryan McLeod (00:01:36):

Yes, I'm here. Thank you very much for the introduction, Keith, and inviting me to speak about my ideas to this committee. And yes, my day job is as a chemical technologist at Canadian Nuclear Laboratories. And full disclosure, these ideas are my own and do not represent CNL, although I am trying to push for them to adopt at least some interest in this technology and how it can be used and applied to advancing nuclear technology. And then with my extra time in the last two years I had entered, I assembled a team and entered a contest called Innovation for Nuclear that was hosted for the North American Young Generation in Nuclear. And they were just looking for ideas on how nuclear power and SMRs could apply to the U.N. sustainable development goals. So I had at that point in time been taking an interest in Bitcoin and Bitcoin mining and how it's being applied to different grid applications, whether it be on grid or off grid or behind the meter in various different situations. But I saw a spark of an idea that ignited a passion in me to see.

Rep. Keith Ammon (00:02:43):

Ryan, Can I interrupt you? Could you pull your microphone closer to your mouth? We just have limited hearing in the room here.

Ryan McLeod (00:02:49):

Okay, sorry. Yeah, so it was a spark of an idea that just ignited this passion in me to forward and cheer for this idea that Bitcoin mining can really help to advance small modular reactors and nuclear power in general by offering a large flexible load that can serve well in many demand response applications and anchor loads or power generation assets that we would like to build now and in the future. So right now it's an incredibly exciting time to be an advocate for nuclear power. There's a spotlight on the technology for good reason many nations are concerned about their energy security and reliability and making sure that it can provide affordable electricity to their citizens. While at the same time trying to electrify everything and reduce emissions with power sources that they're using to do so. And it seems like an obvious choice at the moment that nuclear power should be playing a significant role in doing so.

(00:03:47):

And we have an opportune moment to leverage our license designs like building more Vogtles, building more Barakahs, competing with other nations like China and Russia in these markets to really prove that we have the capabilities that we once had in developing these technologies. And as a resident in Ontario, I have the same feelings about Canada's CANDU technology and recent announcements like the expansion of the Bruce C reactor site and financing commitments for the Cernavoda three and four reactors in Romania. And then also Canada is courting many of the companies that you've already heard

from at this committee for building small modular reactors at various license sites that Canada has for various applications like Moltex, Ultra Safe Nuclear Company, Arc Energy. There's at least 12 SMR companies that are applying forward licenses in Canada. So that is a great interest in the range of markets that SMRs can apply to.

(00:04:49):

So Canada has lots of remote opportunities, lots of small grids, we have good ports for exporting technologies like this and developing clean energy industrial parks. And then one other thing that we do at CNL that's a part of this endeavor is that we have a hybrid energy system modeling team that is developing different scenarios for how to deploy small modular reactors alongside other technologies to basically apply to off-grid mining, off-grid communities, small grids and see how we can fit technologies like intermittent winded solar generation with batteries, thermal storage, and other different demand response technologies to have a well-balanced small energy system that's reliable and affordable for everybody that's participating in it that ideally will have at the core a small modular reactor or in some cases large reactors that we're familiar with.

(00:05:53):

So I won't continue belaboring the point too much on nuclear power because you've already been presented many of the different ideas that they have proposed, whether it be new safety features and coolant types, the various cost outlooks and the product market fits that they're applying to. I've seen that Meredith Angwin was here to speak about her book, Shorting the Grid, and the various complexities that grid managers have to deal with, whether they be physical constraints or political endeavors.

(00:06:22):

But from learning about bitcoin mining and how it can be applied to different grid applications, many of these problems can be addressed significantly. The one being that just having a load that can pay generators for their electricity when market demand is zero or less than zero when it can be distorted, whether it's by excess subsidies that can distort the auction markets or just excess capacity that comes on at various times of the day because we have intermittent sources trying to integrate with base load sources and sometimes that can put lots of economic stress on base load generators as I've read it throughout that many of the stories addressed in Shorting the Grid.

(00:07:13):

So by having an anchor load, we can maximize the economic utility of the power assets in any market environment immediately once we have power generating. Because it's another factor that needs to be considered is the cost of capital in these assets. Like building nuclear reactors can be significantly high, especially for the large reactors where I think an example is the Hinkley reactor that's being built in the UK. Almost 60% of the cost of building this reactor is just paying and servicing the debt of building it. So any means that can maximize the monetization of a power asset as soon as electrons are available to start flowing, whether you have transmission constraints or not will be disproportionately advantageous to the power asset owner because it will allow them to start servicing their debts and getting their capital requirements and capital allocation in order a lot quicker and getting our return on investments completed a lot sooner, which in turn improves investor interest in these big projects.

(00:08:24):

So I was going to go on with a slideshow. I have just going through a few ancillary programs and demand response programs and then getting to how Bitcoin mining is kind of working under the hood, just to give you guys an idea of how it can actually be applied as a very flexible computing technology that we

can use in many different scenarios to improve the economics of generating electricity. So wait presenter view, is that showing good for everyone? Yep. Excellent. Cool. Thank you. Alright, so most of you'll be familiar with all of these ancillary grid programs. They're all just various ways to adjust customer demand and usage of their electricity to off peak times to account for just various grid realities and political incentives that are forcing different generators onto the grids to service whatever their wants and demands are at the time. So in various ways they take advantage of customers that can be pulled together or incentivized to shift their demand.

(00:09:48):

And then just the importance of having grid demand is that it improves the integration of these different sources and makes them able to cooperate better. It improves stability by curtailing demand and shifting to off peak periods and it can reduce reliance on peaker plants, it approves the efficiency of your systems so that you don't need as much additional power and transmission upgrades. But if you were to add additional power and transmission upgrades, they can serve as a buffer while those programs are being added to your grid. Reducing reliance on peaker plants overall can reduce the overall emissions footprint of your grid altogether. And in some cases adding a load on demand can be just as impactful as shedding loads given certain circumstances.

(00:10:34):

They enhanced reliability during extreme events where there's increased strain on grids. By shedding their load, they can make more electricity available for the grid to distribute to higher priority customers. And keeping lights on at hospitals and essential services during extreme events. Offsets these new demand patterns that we're starting to see as more intermittents are entering the grid and we're seeing a lot more electrification of vehicles, a lot more electrification of industry, we're going to start seeing new demand patterns and having technologies that can help us shift those demands and balance the grids will be extraordinarily beneficial. They can also compliment battery storage by better matching demand patterns.

(00:11:19):

It enables capabilities to react to disruptions with varying degrees of responsiveness. The Bitcoin miners have a great degree of responsiveness as I'll get to later, and then it helps the system operators better reflect your total power market pricing by having all of these ancillary markets added together to basically give everyone a better idea of what their electricity costs look like by having a full system perspective and then just a bunch of simple properties demand response that makes a good demand response technology that can go through how tolerant are they to interruption.

(00:11:58):

Are you going to disrupt a product line? Are you going to be disrupting consumers, making homeowners uncomfortable or residents of commercial buildings? How predictable is it? Can it be relied upon when it's needed? How big is it? Is it sizable loads? Large loads can have much larger impacts, scalable loads that can be matched in right size two year varying supply and demand profiles. How quickly can it recover? What is the cost of interruption again, basically things like spoilage or loss production available of alternatives. Like some industries have backup power that they can rely on if the grid requires reducing their outputs towards certain industries during extreme events. Storage capacity like batteries and thermal storage can be displace power usage. Having advanced control systems is very beneficial because they can be remotely controlled and or signal to respond to things like grid price, grid frequency. They can be extraordinarily responsive at very high degree within seconds of any disruptions to the grid when they're called upon, they have good communications capabilities and basically they have two-way relationship with the grid operator and the large load. It's good. Yeah, the larger the load,

the more communication you're going to want to have with the grid operators. Like how flexible they are, contractually. Many of these miners especially will offer good flexibility in exchange for just lower rates. Safety considerations - is shutting down this operation, putting anyone at risk, so you don't want to be shutting down critical infrastructure and the frequency of operation, how often is it operating and how flexible can it be? Can we shift it to different demands of the day?

(00:13:51):

And then I just have here just a list of different technologies that we'll see we'll be familiar with that are used for these services, whether it's boilers, batteries, desalination, data centers, there's a lot of interests nowadays on hydrogen and desalination. There's a lot of hope that hydrogen can serve many of these roles, but again, it's still not a mature technology and there is certain risk with storage and transport of materials like hydrogen, but where you have industries and uses for it immediately where it's being produced, it will have an incredibly great benefit to those communities. But there's still a lot of work to do to develop the infrastructure for a full hydrogen economy, although they'll be greatly supplemental. And then most would be familiar with various metals and chemical industries. They're often used for demand response because they can wield the sizeable load that can be curtailed at times of high grid demand. But what I'm here to talk about is Bitcoin miniers. Because they're the type

Rep. Keith Ammon (00:14:53):

Hey Ryan, can we just stop down for one second? So the previous slides that you went through, let's just rehash that there was a lot of information in there. You were talking about demand response. So the reason that we need demand response is because demand goes up and down and generation has to follow those peaks and valleys. And with intermittent renewables it makes it even more challenging. So there's two slides ago you had a list of all the things that a good demand response would need. So that list there is what a perfect demand response would look like if it checked all those boxes.

Ryan McLeod (00:15:35):

The more of these boxes checked off, the better it is

Rep. Keith Ammon (00:15:39):

As a demand response.

(00:15:42):

And then your next slide is all the different possible demand responses.

Ryan McLeod (00:15:48):

And most of these are in common use today to varying degrees.

Rep. Keith Ammon (00:15:53):

And then you're going to tell us why Bitcoin checks a lot of those boxes. That's what yes,

Ryan McLeod (00:15:58):

That is what I was heading towards

(00:16:00):

And going through. And basically, yeah, sizing up Bitcoin mining against those criteria that were just listed. So things like its tolerance to interruption because of the way that they're computing in a global

network shutting down locally has no effect on the global computing network. So the only thing that they are doing is foregoing potential rewards that they could be earning while they're operational. And one interesting feature that's being learned about and experimented with is under clocking of these computers. So not completely turning them off, but reducing their power consumption has been shown to increase their efficiency. So they will be able to do more computing with less electricity, but overall they would be able to still reduce their load from, say if they're operating at 100 megawatts, they can reduce to 10 megawatts and still be operating just at a much lower power input.

(00:16:57):

And essentially they can be disrupted to any degree in between from one to 2% in sleep mode to 100%. So they provide incredible degree of flexibility and then they're predictable because they have a very consistent and predictable supply profiles depending on the generation of the ASIC, the application specific integrated circuit that's basically the name given to these computers, they all have different efficiencies depending on the class of machine. And the efficiency is measured in joules per terahash, which I do get into more detail about this later. But that is essentially how much electricity does it take to perform 1 trillion computing operations every second. And the newer ones are getting down to using about 20 joules per terahash, whereas older computers are in the range of 80 to 90 joules per terahash. So there's a significant difference between the different ages of machines that you're implementing.

(00:18:01):

So you can have, so yeah, most miners will average about amongst their whole fleet to come up with the total efficiency of their fleet and then they can be used as a much incredibly sizable load because they could consume as much power as a small city from the footprint of a small farm. And some of the largest Bitcoin mining facilities have been earning a sizable portion of their revenue by reselling power that they have owned on contracts. We have a power purchase agreement for say 4 cents kilowatt hour in ERCOT when the wholesale power market exceeds 4 cents kilowatt hour, they now have the choice to sell that block of power back to the grid. And in some cases that the wholesale power prices were spiking to as high as a dollar plus per kilowatt hour. So they benefited greatly from engaging with the power markets as well as mining Bitcoin. They're very quick to recover. I wish I had a graph of that, but there are a few companies that are showing that they can very quickly drop their load and shed their load when it's called upon within a few seconds so they can play all of the different demand response markets, whether it's the day ahead market or the hour ahead or 15 minutes or even right down to the level of frequency modulation.

(00:19:26):

The cost of interruption is basically just quantifying how much they would've lost if they were mining Bitcoin and financially incentivizing them with incentives from the grid operator for providing them service. They also have very advanced control systems and many of these mining systems are equipped with automated curtailment software that monitors the key grid signals. And depending on the ancillary program that they're enrolled in, there's software companies like a company called Foreman that provides miners with the fleet management software that allows them to control all their entire grid remotely. And they can even offer the RTO/ISO managers insight and control of their fleet when they enter into these different partnerships and contracts and that are often very flexible and mutually beneficial to all of the parties because they're just trying to secure lowest-cost power and they offer many services of curtailments in order to get lowest-cost power.

(00:20:26):

And one that I wanted to add to it is that has a very low learning curve. Bitcoin mining is something that anybody can learn how to do. Most of the miners out there began as home miners starting with as

hobbyists with one or two machines in their home. And then they started learning about power markets and how to source power agreements as they grew into the large industrial scale mining businesses that we see today. So there's no reason the power asset owners could not easily develop the required skillset to mine Bitcoin for themselves. And they also have the option of entering into power purchase agreements and partnerships with experienced existing miners that would be more than happy to help them advance the deployment of their small modular reactors. Or there is an engaging or they can engage for the consulting firm like Amanda Fabiano started one called Fabiano Consulting (https://fabiano.consulting/) where she is leveraging her network of experts in the mining space to offer expert guidance and mining strategies for basically anybody that can come and approach them with a problem that they have with whether it's a supply and demand mismatch or there's heavy curtailment at points in the grid, they would be able to provide you with the correct, the best experts to help you address specific situations like that.

(00:21:43):

And then on top of that, there's websites like Hash Rate Index (https://hashrateindex.com/) and Braiins Insights (https://insights.braiins.com/) that offer miners with all of the essential bitcoin mining data and some profitability calculators for different computers that work at different efficiencies at different electricity power prices. So all of the tools that anybody would need to get heavily into Bitcoin mining are available for anybody to access at any time.

(00:22:09):

But what is Bitcoin in general? As power providers, we really should be just mostly thinking about it as a digital commodity. It's a commodity just like aluminum, just like steel, just like gold. We mine them, we would find them and we embed energy in them and they have a value on a completely different market for different reasons. And the reason that Bitcoin is valuable is that it serves as a very good value transfer mechanism in the digital space because the issuance of all 21 million Bitcoin is governed by simple equation and the difficulty adjustment that enforces that there will only be a block issued roughly every 10 minutes. And then Bitcoin is a digital ledger that achieves consensus on the legitimate state of ownership and custody of who owns the Bitcoin in a zero trust permissionless way using a globally distributed network of nodes that update synchronously, which is a stark contrast to our traditional financial system that is very permissioned, requires trusting third parties. It is very centralized and we are trusting the banks to update the state of ownership and the custody of our wealth.

(00:23:20):

But notice here I also, I have Bitcoin with a capital B and Bitcoin with a small B. It's a simple way to denote Bitcoin the commodity and bitcoin the blockchain as two separate entities as I kind of show here as Bitcoin is something that can settle a transaction whereas bitcoin the network is the plumbing that can move the money from ownership from owner A to B. Essentially what miners are doing is facilitating the transfer of ownership. And this is just a simple graph to contrast centralized, centralized ledger versus a distributed ledger and just showing that Bitcoin can be participated in by everyone, whereas banks and clearing houses require a lot of permissions to participate in. And essentially Bitcoin has found a way to upgrade technology like this that hasn't really seen an upgrade since double entry ledger accounting in the 14th century.

(00:24:19):

And this is the equation that governs it all. The first blocks were worth 50 bitcoin and that was applied to the first 2010 blocks on the Bitcoin blockchain. And each block is essentially a ledger entry that is a batch of transactions. So by processing the first 210,000 blocks of transactions, miners were rewarded with 50 bitcoin for each block. And then as I increments up one, that 50 gets cut in half to 25 to 12.5 to

6.25 to 3.125 and reduces in a scheduled manner that's predictable right down to the very last Satoshi that will be mined sometime in 2140. And it is the miners combined with the nodes and the difficulty adjustment that enforce this equation that enables us to predictably know when all the Bitcoins will be issued, when the "havings" are going to be, when adjustments are going to be made to the difficulty. I found this to be an interesting way to just illustrate Bitcoin's issuance rate and just showing that roughly half of the issuance of all Bitcoin will be in each key box. So the first half of the 21 million was issued in the first four years and then the first half of the remaining 10.5 million was issued in the second four years and so on and so on. And it cascades into the middle of this Fibonacci circle.

Rep. Keith Ammon (00:25:56):

Hey Ryan, can I just stop you down there?

Ryan McLeod (00:25:59):

So

Rep. Keith Ammon (00:26:00):

The subject of how Bitcoin works is very complex and I it very interesting.

Ryan McLeod (00:26:06):

I didn't want to get too deep into the weeds, but I wanted to at least.

Rep. Keith Ammon (00:26:08):

Let's not get too deep, but the idea is that the issuance rate gets cut in half every four years. That's basically the, and it creates scarcity, which makes it valuable. That's kind of the main idea. But could you tell us more about let's say, so we're a merchant generator plant regional grid, so we need to figure out a way to privately raise enough capital to have SMR projects, especially in our state because we don't like to subsidize things.

(00:26:43):

So could you tell us how, let's say we have an empty plot of ground and we have the permits that we need to put an SMR on the empty plot of ground. How would mining help us do that and make the financials of that more favorable? Could you just explain that to us?

Ryan McLeod (00:27:02):

Simplest way would be that it provides certainty of demand. It gives you a guarantee that you'll have a customer for that electricity regardless of what your local environment looks like. Whether you have your transmission connected by that time or you have other customers available, you can apply mining to consume your full load or just a partial load depending on what that looks like. And by doing so, it will improve the interest, it'll just improve the confidence of investors that are looking to be part of these types of projects that want to deploy SMRs in remote communities. It'll be beneficial to the company that wants to sell the SMR because it will open up a much wider customer base and it enables the merchant owned operators to further to expand beyond what they initially could have because they know that that placeholder is available to consume that electricity regardless of whether or not a community grows into it, whether there's transmission interconnection delays that they have to deal with, which is something that we're seeing a lot of with many new power projects especially.

(00:28:14):

Another thing to consider now is that the institutional investors taking an interest in Bitcoin as well. So big money like the Bitcoin ETFs being proposed by BlackRock and many of their other competitors are showing that there is a lot of assets under management that are looking to allocate even just a small portion of their treasuries towards something safe and that they can feel confidence in like a Bitcoin ETF offered by a credible institution. And it gives it a lot more cover for talking about Bitcoin in a more open way in environments like this because yeah, talking about Bitcoin money even just a few years ago was still kind of magic internet money and it wasn't taken seriously. But now that we have certain investors that are entering this environment, we're going to see more money start flowing into how can they obtain more Bitcoin and then that spirals into if they want to protect the asset that they now own, Bitcoin mining is an obvious way to start doing that.

(00:29:17):

So they're going to start looking for projects that they can allocate capital towards to start facilitating more Bitcoin mining in a more distributed way that gives more confidence and more security in the immutability of ledger and protects it from being overturned. One interesting thing, because I know I'm probably getting short on time that I did want to mention that the importance of the immutability of the network essentially is that can't be counterfeit and once a block and a transaction have written to the blockchain, it's all but impossible to go back and make that change. So recently in Guatemala they were able to use that to their advantage to timestamp their election results into the blockchain so that anybody can verify the results that were coming directly from each election table in their election that they had just a few months ago. And it was very successful and it looks like it's going to be attempted to be replicated in different jurisdictions.

(00:30:14):

So one random other use besides the transference of value that has manifested from using this Bitcoin ledger. And so miners are protecting things like that. So not only just the value transfer, they can be protecting things that are timestamped in this ledger that are very important documents like election results that we can then refer back to and have confidence in the integrity of something like our elections. Not to stress it too much, but election integrity has been a hot topic in recent years, especially in America and Canada. And it's very important that we can have a mechanism to provably verify results and this seems to be an interesting way to do so. Yes,

Rep. Keith Ammon (00:31:03):

Ryan? Yeah. So the immutability of the ledger is a critical idea. Could you give us real world examples of how this may be being used currently or in the pipeline in the near future so that we just can get our heads around it?

Ryan McLeod (00:31:18):

Yeah, I'm just going to skip ahead to one here. These are just graphs you could find on Hash Rate Index for the cost of miners, the difference of operating expenses and capital expenses for different generations of miners. A metric called the hash price that helps easily quantify profitability. This is just a snapshot of the blockchain from the mempool and want to get to this one? Yes. A few examples of how this can be applied. So we have the obvious first sets with at-home miners, which is a small amount of electricity, two large industrial scale miners that are commanding the amount of power as a large city or a small power plant. So some of the examples that I've found the most interesting are the ones that are

packaging miners into shipping containers alongside a generator and they will find off grid opportunities to mine off of natural gas.

(00:32:13):

One of the most interesting ways that they're doing that is they're operating on flare stacks, so they're reducing methane flaring into the environment, which is greatly beneficial, and then they're also starting to find ways to do the same at landfills and agricultural methane emission sites. So that is showing great promise at reducing emissions on those. There are some that are finding homes near wind and solar sites where they can flexibly operate amongst the intermittency of those types of generation and then they can balance their relationship with the grid. Basically they can just offer a digital conduit that when they're generating excess capacity, they have an optional secondary market that they can sell that electricity for a non-zero price instead of having to curtail it. And then this last one here shows a liquid cooled immersion mine, just a different way to cool miners instead of the standard air cooled mining methods they use where they just blow fans.

(00:33:14):

And that has caused complaints in some communities where these have been built because the fans can definitely be loud in their efforts to cool these machines down that put an awful lot of heat. But getting into heat, that heat can also be used as a product for various other markets. Many of the home miners are finding ways to used in the space heaters to bring them into their hot water tanks, their pools, hot tubs, some miners are using for greenhouses. And I think a recent one that's been announced is Marathon Digital Holdings, one of the largest miners in the world, wants to partner with an aquaponics shrimp farm to provide the heat to that facility. So there's all kinds of interesting different side applications that we use for these bitcoin liners, but just in general, they take up a false small footprint and they can be sited, they can be used in easy transportable methods by placing in shipping containers and they're just dropping a set of shipping containers if you don't expect for them to be needed for long-term if you only need them for four or five years.

(00:34:19):

And then they can be redeployed to other jurisdictions that have better power prices depending on what the market's doing. Or if you expect to be a long-term customer in some of these facilities, you can set up a large fixed industrial data center that hosts these computers. And many of them are also now starting to offer co-siting opportunities for AI computing, various high performance computing. And that gets me to one example that I want to explain before we wrap up is the one that NuScale just announced a partnership with a company called Standard Power. Standard Power. Well they haven't really done much yet. They're hoping to build a large data center at the site of a coal plant that they purchased. The coal plant has since been retired, but they still have access to a 1.2 gigawatt interconnection line that they can sell or draw electricity to from that grid.

(00:35:18):

So their game plan for the next few years is to build up a data center site that will be able to fit into that one-ish gigawatt size frame. And then as the SMRs from NuScale start breaching maturity, they want to deploy those reactors to replace the coal generation that used to be at that site and ramp up in a sequential way that they can maximize the utility of the reactors with. I think they want to go as much as 12 modules when all is said and done by 2035 or something. So they definitely are thinking the long term for these relationships with the power companies that they're engaging with. So there's any number of different ways that that can be applied for a market such as yourselves where you have the operator owned of assets and they can just buy pre-made prefabricated shipping containers full of

mining equipment, or they can build custom data centers that are just act as hosting for other companies that want to host their computers and they will pay rental space for the rack space.

(00:36:27):

And it just depends on what kind of risk sharing models that they would want to apply, whether they want to go vertically integrated and take all the risk but earn all the rewards or share the risk amongst multiple parties by hosting or entering into joint venture operations. But it is a pretty wide open field for many different ways that it can be configured. The one thing that just seems to have gotten some of the miners in the last bull run was debt management where some miners took on too heavy of debt obligations and it caused them to get over-leveraged and then they had to declare bankruptcy and sell some of their equipment. But for the most part, the miners that have survived this recent downturn in the market, they've proven incredibly good risk management strategies and debt management strategies and growth, slow steady growth strategies that are showing great promise for being redeployed to many different markets.

Rep. Keith Ammon (00:37:28):

There's a company called TeraWulf. Could you just talk a little bit about Wolf?

Ryan McLeod (00:37:32):

Yes. Don't want to forget TeraWulf. TeraWulf is the first behind the meter Bitcoin mining site at a nuclear power reactor. TeraWulf owns, I think they have a relationship with Talent Energy who owns the Susquehanna nuclear power plant in Pennsylvania. And so they've offered entered into a partnership with TeraWulf and a company called Cumulus Coin to build up several hundred megawatts of data center capacity that will be filled mostly with Bitcoin miners to offer the flexibility and then also offer hosting spaces for other data center facilities that would be interested in that type of hosting arrangement.

Rep. Keith Ammon (00:38:14):

Alright, great. If you could wrap up in the next 60 seconds and then we'll move on to our next guest. Just waiting in the wings here.

Ryan McLeod (00:38:26):

Yeah. So SMR, this is just a general idea, it just shows versatility. The Bitcoin can be put in key junctions, whether it's your generators, whether it's your interconnection stations, and even at your end consumers and just absorb your excess electricity, just play a buffer role that reduces your reliance on other consumer loads. And this is just a more detailed version, just shows each step in those facilities and then how it can be parlayed into maintenance funds and capital investment funds to further improve the stability and quality of your grids. These were a few things that I can quite have time to get to, but Synota is an interesting one because they are creating software tools that will enable customers like Bitcoin miners to pay for their utilities in real time. So essentially as electricity is being consumed, they want to enable you to be able to stream Bitcoin back in real time and be able to pay everybody that is part of that value chain instantaneously will be compensated as that payment is facilitated. So it has a pretty interesting potential to reduce accounting overhead and complexities of month ahead billing and the credit risk associated with that stuff. So they haven't announced their product yet, but that is something to keep an eye on in this space.

(00:39:50):

And just in my conclusion that it did, yeah, Bitcoin and Bitcoin mining in general is being recognized by a lot more institutional investors and it's getting a lot more credibility in the markets from people that would've otherwise just left it as an internet oddity or as it has been for the last 10 years or so. But then because it's here to stay, the question really does remain, what do we do with it? How can we take advantage of it? And I believe confidently that we can use it to take advantage and advance the deployment of nuclear power and we can greatly benefit all of humanity and the environment. And my hope is that I've given you all some new ideas to consider about how we can reimagine our relationship with power markets and how we generate and consume electricity.

Rep. Keith Ammon (00:40:38):

Alright, great. Just to interject one quick thing, that's New Hampshire related. You mentioned about under clocking and like fleet management software and you also had a slide of the methane generators with the shipping container size mining rigs. So both of those things, the firmware and the mining rigs, a company called Cathedra, which has a manufacturing facility in Berlin, New Hampshire, they create the shipping container mining rigs, but they also have a new product for firmware and under clocking, which is kind of interesting. We have a question.

Ryan McLeod (00:41:17):

Yes. They're the ones that were actually doing the experimentation with the under clocking showing that they can generate more computing with less electricity. So it offers them just new interesting strategies for their power management, especially when the market sinks and their cost to mine Bitcoin goes up significantly.

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

So I just want to throw that that's a connection to manufacturing in New Hampshire, which is kind of cool. So we have a question online, could you stick around for later maybe if we have questions for you because we need to move on to our next guest?

Ryan McLeod (00:41:49):

Yeah, absolutely. Sorry.

Rep. Keith Ammon (00:41:52):

So we're going to let,

Ryan McLeod (00:41:53):

It's a big idea to pack it too.

Rep. Keith Ammon (00:41:56):

It's a lot of information. So Paul Guntner, he has his hand raised, he's going to ask you a question and just be ready for anything Paul asked really tough questions. Alright.

Ryan McLeod (00:42:08):

Right on.

Rep. Keith Ammon (00:42:09):

Go ahead Paul.

Paul Gunter - Beyond Nuclear (00:42:10):

Thank you. Yes, Paul Gunter, I'm with Beyond Nuclear and we're working with constituents in New Hampshire on this issue, but Representative Ammon asked about how nuclear power and Bitcoin are currently interacting. I think we'd be remiss without bringing up the recent report that came out mid-October by Iceberg Research that was looking at the relationship between Standard Power and NuScale. So NuScale as you mentioned, put together a sale agreement with standard power for 24 77 megawatt SMRs, which are still uncertified, but nevertheless it was a 37 billion dollar deal. And I think that everybody should pay attention to what Iceberg research has put together because without going into great detail, you may be familiar with it, but it's done an incredible damage to investor confidence where there are now lawsuits forming as a result of the release of this report by investors in NuScale for the Bitcoin development in Ohio and Pennsylvania. So I just wanted to interject that I'd be happy to put the report from Iceberg Research into the chat for the New Hampshire Commission.

Rep. Keith Ammon (00:44:07):

I can add a few details to that. Iceberg Research is a short seller, so they're trying to make money on tanking NuScale stock. So that's their motivation and NuScale has responded to that and it's still kind of a fluid situation. So Iceberg has their opinion, Standard Power and NuScale have their position and I think that's, it's still shaking out, but that is a point to bring up, Paul.

Ryan McLeod (00:44:36):

Yeah, I definitely agree.

Paul Gunter - Beyond Nuclear (00:44:38):

You can ask specifically, but I think that more broadly it's also a concern for NuScale because they are under subscribing right now with the UAMPS in Utah for their project with Idaho National Labs. And the timing here is critical for NuScale in that they've got now controversies in several Western states that have been complicated now by nuclear power venture into a very controversial Bitcoin, which is making national headlines as you well are well aware. Thank you.

Ryan McLeod (00:45:32):

And those are definitely great points and it is a concern they may have gotten over their skis announcing such a big project well in advance of it, them even proving out a small scale operation. I think once Standard Power starts proving their capability of building data centers and gets a little off the ground, these concerns will be a little bit more alleviated. But yeah, it is a interesting new territory that we are navigating with these technologies because another place where Bitcoin mining is existing, it's more tangential to nuclear, but it's not directly behind the meter, is in Georgia where they built their new Vogtle reactors, CleanSpark has a very good reputation for the way that they're building data centers in some of their grid co-ops locations that they have sited throughout there. So it does come down to making sure that you have good relationships with the communities that you're building these things in just as much as the power brokers that you're going to be engaging with.

Rep. Keith Ammon (00:46:40):

Alright, great. Thank you Ryan. That was a lot of information to digest. You're welcome to stick around. We may have questions for you at the very end, but I can't promise you that I'm going to move on now.

Ryan McLeod (00:46:52):

Yeah,

Rep. Keith Ammon (00:46:53):

I hang on. Well

Ryan McLeod (00:46:53):

I definitely want to catch the Kairos and the NANO presentation, so I'll be here.

Rep. Keith Ammon (00:46:57):

Okay, so Evan and James, I think James, I had you scheduled first. I know you're at another meeting and so I don't know if you can Yeah, I was here for the nine 30, so obviously it was a bit past that. Now we are past that. Yeah,

Ryan McLeod (00:47:20):

My apologies.

Rep. Keith Ammon (00:47:23):

Don't worry, Ryan. It was interesting presentation.

James Walker - NANO (00:47:30):

I was just going to say, obviously I can let Evan go first if he's in a rush as well. I probably wouldn't be able to stay on past Evan's call to do my presentation as well, but I could leave the floor for Evan if that's more interesting.

Rep. Keith Ammon (00:47:53):

Yeah, why don't you go ahead James. Okay. So James, you're representing NANO.

James Walker - NANO (00:48:00):

NANO Nuclear Energy. Yes.

Rep. Keith Ammon (00:48:03):

And you're the CEO and you're the head of reactor development.

James Walker - NANO (00:48:06):

That's right, yes.

Rep. Keith Ammon (00:48:08):

Alright,

James Walker - NANO (00:48:09):

Right. Well I'm please meet you all Evan, I'll try and be a bit quicker just so you don't have to wait too long,

Evan Cummings - Kairos (00:48:15):

James, that's very kind. Thank you.

James Walker - NANO (00:48:17):

Alright, no problem. Well, I do have a presentation, but just before I jump onto those slides, I think just a bit of background about why Nuclear in New Hampshire is a good idea because we didn't start with the idea that we would go for nuclear power either. It was really the only solution that was when we examined all the options available, that was the only option we could really take as a business and we considered other options, renewables, solar, wind. And when we actually began to look into it, we realized that if you're trying to decarbonize as an example and you want to put in a wind or solar farm or plant, they're very locationally dependent. They need an enormous amount of land mass, they're very intermittent, they don't have very high capacity factors and the storage costs alone can be enormous for these powers. And that alone meant that when we were trying to target industries that were being underpowered, nothing except small nuclear was adequate.

(00:49:27):

Nuclear has the most consistent form of energy, most the highest capacity factor can be put anywhere you want. It's not locationally dependent as it doesn't need good sun conditions or wind conditions or anything like that. And when we began on examining the nuclear space, we became to the conclusion actually that SMRs were very interesting. But actually if you go a bit smaller than that and you go into the microreactor space, then that's the potentially much larger untapped market because you're then looking at remote mining sites, industrial sites, oil and gas sites, disaster relief areas, military bases, chemical plants, as Ryan was talking about, Bitcoin mining data centers, charging stations for EV vehicles. Microreactors can be applied to all of those in a way that other renewables can't. And so that's the direction we took and we realized that if we wanted to make a successful business, obviously you'd have to be able to compete almost with diesel generators because that's what you're competing with, not other renewables.

(00:50:33):

And so the idea then was to go out and find technical teams that would develop reactors that could fit within an ISO container that could be deployed anywhere, that could use conventional transportation infrastructure such as going on trains, trucks, ships, it could be deployed anywhere in the world and put down somewhere. And so with that in mind, we reached out to a couple of technical teams and the first team we reached out to, the first team we reached out to was out some professors and scientists based out of University of Berkeley, California. And we gave them the MO of this needs to be portable, it needs to be compact, it needs to be incredibly safe and it needs to be pretty much unmanned. We need this to be able to be essentially even just one or two physical people can be at site. And we want this to be remotely operated. So we have a central location where we could potentially deploy hundreds of these different reactors.

(00:51:42):

It could be where the behavior and the characteristics could be monitored and adjusted through a remotely and then you would just have one or two physical persons at site in charge of security and any sort of physical intervention that would be needed. The advantage here as well is that if you shrink

down the reactor to essentially a micro reactor size, it gets an order of magnitude saved because you can then have passively cooling mechanisms, passive cooling mechanisms built into the reactor. And the benefit of that is the biggest accident scenario that you can get with a, say a large reactor civil power reactor is a coolant loss followed by core melt and then you've got a cleanup operation in your hands. No one's going to die in that sort of operation, but it's still a mess. But with a micro reactor, because they're so small, they naturally radiate heat to a point where they passively cooling.

(00:52:33):

So even if every mechanical instruments and mechanical component within the reactor was to break simultaneously, the reactor would still operate completely fine and it would just passively cool so they could be fixed. And with that in mind it becomes even safer. It's worth pointing out that nuclear is already the safest form of energy. If you would look at something like deaths per gigawatt hour generated, it already beats up wind and solar and that's the civil power class. SMRs are safer than that. The micro are even safer than that. And the good part about these things is you could deploy hundreds of thousands of these around the state really, and there would be very little risks at these things.

(00:53:15):

So aside from, is that the right slide? So just a little bit about the reactors quickly, and I'm just trying to be a bit quick for Evan, the University of Berkeley, California professors and scientists that we were working with, they came up with solutions for our MO, just creating a solid core battery reactor. What that means is we've removed the cool and completely and we have conventional fuel rods. So we are using old technology that we know works that have big data sets and we thermally conducted heat through a solid matrix out to the periphery of the reactor where just normal air removes the heat to a basic gas turbine. It's basically the most simple reactor you could possibly make. It has very few working parts. It's incredibly safe. And again, it would not need any, anybody who was deployed with a reactor that was just there for maintenance work would probably have a very boring job.

(00:54:14):

This thing would be deployed to site, it would be able to operate for 10, 15 years and it would be able to supply high capacity factor energy consistently. And the good part about this reactor as well is that it operates at a higher temperature. So if you are interested in the manufacturer of hydrogen for instance, the higher temperature you go at the more efficiently you can manufacture hydrogen. And so the Zeus reactor operates at those sort of SMR higher temperatures, much higher than civil reactor. And so you get that efficiency. So say you're not using the power, so your full capacity at nighttime for instance, when your base load might be requirements might be lower. You could manufacture hydrogen at that point for the benefit of using that for say a mining site that might want to run vehicles or something like that. And the other reactor, just to de-risk the company further, we went to the University of Cambridge in Europe and we asked them to, we gave 'em the same MO small modular can be shipped anywhere, very few working parts and they came up with a solution using solar salt again, has a passively cooling mechanism built into it.

(00:55:29):

Very few and it operates at a much lower temperature, but it has a much higher megawatt thermal output. So they might have a different industrial processes, but this would last for a lot longer. Again, would not need any refueling. The way these things would be deployed is that you would move the reactor site, it's very likely we would fuel at site once the reactor had finished its lifetime, it would be defuel, the reactor would sit there for a year and then at that point it can be just conventionally scrapped. The idea here as well is that we wanted to remove the liability from anybody who wanted to have these reactors. So it's very likely the business model would involve not even selling the reactor, we

would lease the reactor or lease the power to a company over a set amount of time. So say they wanted a 10 year or 15 year contract, we would lease the power to them over that lifetime and we would operate it for them as part of an ongoing expense. And then once finished, we would actually completely remove and reactive from sites. And so any sort of customer would not have those upfront, those high upfront capital costs, costs and they would also not have to worry about the operation of this or the removal of this or cleanup and we would take care of all of that and that would be one of the major advantages of microreactors.

(00:56:55):

Okay. Evan, I was as quick as I could be.

Rep. Keith Ammon (00:57:01):

Sorry for that jam up there, James. We appreciate you going through that quickly. No problem. I'll ask you later for your slides and if you can always decline to give them, but we can post those on our website for people,

James Walker - NANO (00:57:17):

No problem at all. I'll send those off.

Rep. Keith Ammon (00:57:20):

Alright, great. And just quickly, any questions for James? Any questions online?

James Walker - NANO (00:57:37):

Okay.

Rep. Keith Ammon (00:57:38):

Alright, thank you. So I think people are just concerned about the time, that's all.

James Walker - NANO (00:57:42):

Alright. I was also a little bit concerned, so great, glad we

Rep. Keith Ammon (00:57:47):

Thank you and we may follow up with you later if we have further questions.

James Walker - NANO (00:57:50):

No problem. Alright, thanks everybody.

Evan Cummings - Kairos (00:57:51):

Thanks James.

Rep. Keith Ammon (00:57:53):

Thanks James. Alright, Evan, you are up.

Evan Cummings - Kairos (00:58:03):

Alright, thank you very much.

Rep. Keith Ammon (00:58:10):

And just a quick introduction, I you work for Kairos Power and you're the director of business development there?

Evan Cummings - Kairos (00:58:19):

That's correct, yeah. So I'll go ahead and get started. I know we're a little behind, so I'll try to pick up some time here. Again, appreciate the opportunity to speak and thanks Keith for trying to be flexible with the time. As you mentioned, I'm director for business development for Kairos Power and what that means at Kairos is my main objective is to catalyze the commercialization of our advanced reactor technology. Before ending a meeting or presentation. We always remind each other and others that we're speaking to of our mission and that is to enable the world's transition to clean energy with the ultimate goal of dramatically improving people's quality of life while protecting the environment. And in order to achieve that mission, we know that we must prioritize our efforts to focus on a clean energy technology that's both affordable and safe. So a little bit about who we are before I get started here, I'll talk about the makeup of the company and then primarily about our timing and what we care about the most.

(00:59:24):

So we are a energy engineering design and manufacturing company and we're singularly focused on one technology. So we're not working on multiple things at once. The entire organization is focused on, and I'll talk about this a little later, a salt cooled high temperature reactor. We were founded in 2016. We have approximately 368 employees that seems to grow significantly every week and 90% of those folks are on the engineering staff. From a schedule standpoint, we're looking to be commercial by 2030 or earlier, and our efforts are all around cost certainty and the way in which we do that, I'll speak to again, but that is to be competitive with natural gas in the US electricity market. Keith, I think it was you who mentioned that New Hampshire does not want subsidies as part of new power generation. That is our goal as well. We need to stand up to the traditional sources of energy that includes not only the renewables but also fossil generation.

(01:00:24):

This slide is in every deck that we talk about, but it's got some meaning here. So in the not so distant future, we'll see the retirement of about 60% of our base load generation from natural gas and 40% of our conventional light water reactor nuclear plants. This graph shows electricity generation by initial year of operation. And the early 2000s there that spike was our Kairos Powers founders Genesis effectively because most of those plants are part of the baseload retirements that I spoke to that are going to happen in the 2030s. And the hardest part about that statistic, and this has been mentioned a couple times, is not only will we lose massive amounts of power generation on the grid, but we're also trying to decarbonize our economy and really only nuclear can provide a stable carbon-free generation source to the grid.

(01:01:18):

You can see this in the top left corner. Kairos means in Greek, the writer opportune moment. And I liked Ryan's comment, he said earlier, he feels like now is the opportune moment. I couldn't have chosen a better descriptor. So appreciate that. We think that the moment is now and we plan to support our carbon free generation needs with an innovative design. And through our strategic development approach, our technology is really the combination of two proven technologies from nuclear's birth in

the fifties and sixties. Those two things were combined to create a cheaper safer design. We use a high temperature molten salt coolant, which is on the left-hand side photo that's from our lab, a small modular design, and we combine those with a solid fuel form called Triose. The DOE calls triose the most robust fuel ever made. I won't explain what that is. I've watched some of the previous videos. I believe everyone on the commission understands what TRISO is. If you have questions about that, feel free to ask them at the end of the call. But it's effectively a higher density fuel form that provides higher amounts of energy and it's much safer.

(01:02:33):

So the technology is not really the biggest piece here. The biggest piece for Kairos power is how we get to cost certainty. We're pursuing five major work streams. You can see those on the left-hand side. Those are being done in parallel to achieve our mission. These in the dark blue on the left-hand side are paired with the four major goals, which are on the middle and the light blue. And then lastly, for one ultimate objective. So first I'll start with the major work streams. Again, these are happening in parallel right now for Kairos Power, the reactor design, a test program, a licensing program, fuel development, and then salt development. Our four major goals, ensuring technology certainty, so providing evidence and confidence that the technology actually works. On the licensing side, I'll talk a lot more about this later, but proving that we can license the technology with the Nuclear Regulatory Commission, not only just with the NRC, but also a license that is suitable for communities and that want us to come into their locations.

(01:03:39):

From a supply chain and manufacturing certainty, we are creating a robust and sustainable supply chain for key components for our design. And we're not scared to manufacture those things ourselves. So that's part of our strategy as well is vertical integration. And lastly, it's to build certainty. So we need to prove that we can build this technology and not let it live on a paper design and hope that someone buys it first and then prove it after. Those parallel work streams, the overall goals, that all gets us to what our final objective is, which is cost certainty. And that's in the green box on the right.

(01:04:17):

A little bit more about our strategy here and how we get to commercialization. We can really only achieve our mission and our core objective, which I spoke about. Last slide, about cost certainty through our strategic development approach. We use rapid learning cycles, we use vertical integration, and then we incorporate nuclear and non-nuclear large scale demonstrations. And this is very similar to the SpaceX tested at scale, how SpaceX tested their at scale rockets before they built their commercialization plan with NASA. So if you're looking at this slide working from the bottom up, you'll see non synchronous iterations that are schedule driven. Those will deliver our commercial reactor by 2030 or sooner. On the bottom you see the engineering test unit, you might hear me refer to that as ETU. That's a series of at scale deployments. Again, non-nuclear at our facility in New Mexico, their prototypic of our first nuclear iteration that we call Hermes.

(01:05:20):

I'll speak to that in a little bit. But the Hermes reactor series will be a fully licensed nuclear demonstration proving our technology, proving our design, our ability to produce nuclear heat, and the series itself will then be prove that we can connect and produce grid-tied power. Keeping in mind by the way, that all the way up to Hermes, which is that first non-power demonstration reactor for 15 megawatt thermal. This is all without a customer. This is all on Kairos' own demonstration pathway. Lastly, just quickly after Hermes, we will scale up that design to a non-nuclear user facility, which is very synonymous with the Engineering Test Unit. Basically it's a testing facility that's at scale for the final

product, and then that user facility will be prototypic of what we call KPX or our first commercial unit, which we're expecting to be 140 megawatts per unit.

(01:06:20):

We've made significant investments in infrastructure to support not only hardware demonstrations, but also facilities across the country. Just really quickly here, our headquarters are in Alameda, California. We have a production development facility in Albuquerque, New Mexico. It's quite sizable and expanding. We have a licensing office where most of our licensing staff is in Charlotte, North Carolina. Right next door in Tennessee, we acquired the former K 33 gaseous diffusion plant site, which is in the East Tennessee Technology Park that's now rebranded the Heritage Center, but that's in Oak Ridge, Tennessee. That will be where we would deploy our Hermes reactor series. It's a quite large piece of land and it's a Brownfield site. And lastly, we've got lab space in New York and a molten salt purification plant, which is hosted by our partner Materion in Elmore, Ohio.

(01:07:22):

This talks a little bit about our vertical integration. So I spoke about this once before, but I'll just quickly share that. We've put efforts in significant investments into infrastructure. I just mentioned that in the last slide. These are all strategies to de-risk our supply chain and then ensure that we can deliver at cost certainty, both vertically integrating production or assembly components and materials that are one of three things. They're either related to our salt, they're safety related, or they're not available off the shelf. So those are the three criteria that we take. You'll see on the top right hand corner that is a surrogate pebble, so that's just a graphite compressed pebble that we use for testing. That's about the size of a pinging pong ball. We are partnered with Materion Corporation for molten salt. You can see that facility on the left-hand side, and then Los Alamos National Lab in New Mexico to support our near term fuel program. And that will be for the Hermes demonstration series.

(01:08:22):

What you don't see all the time are real engineering and manufacturing photos from companies at this stage. We're really proud of our team in New Mexico and how much effort they put through in the manufacturing and fabrication of our design. Here's a few photos of the machine shop in Albuquerque, New Mexico. It also includes a photo of our team standing next to our first U-Stamped Vessel. We actually acquired the ASME certification, which helps us to build components and move quickly in our testing program. You've heard me talk about ETU or Engineering Test Unit. Here's a near final photo of what that looks like. You can see it's quite large.

(01:09:07):

This is the evidence that I think one would need to ensure that you understand we're a hardware demonstration company and we are not a reactor company. So what you're seeing here is what we call Engineering Test Unit One. We will take the learnings from this iteration and put it into our next non-nuclear iteration called Engineering Test Unit Two, and then I'll speak to this in a moment, but there will be a third as well. And so all these will be done on a non-nuclear scale prior to any nuclear demonstration for the company. If you have questions about engineering testing, I'm happy to answer them at the end during questions. But I'll just frankly state that we're taking responsibility for the unknowns related to new nuclear designs right now and we're proving that it works while sharing our learnings with our partners and future customers. We think that that's critical to ensure that we're cost competitive with natural gas and that we can get affordable and clean energy to consumers.

(01:10:13):

So I mentioned our licensing milestones. I'll speak to this. This is actually very, very recent news. First I'll start with Engineering Test Unit 3.0. This is at our Oak Ridge Tennessee site, so it's a rendering of what this will look like. That'll be our third iteration of a non-nuclear demonstration and that will help with testing and training for our Hermes series. Recently we've acquired, or we had our last step in the construction permit application with the NRC that happened on October 19th and we expect to have a construction permit in hand by the end of the year. So I'll just quickly share that construction permit application was accepted for review by the Nuclear Regulatory Commission in November of 2021, and that was following a quite extensive pre-application engagement that we did with them. We submitted 11 topical reports, which previous presenters have shared that they're paid reports to get the NRC a good understanding of what's to come in the final submissions. It's very helpful. We're the first and only developer, by the way of a non light water reactor to have a firm NRC review schedule for a construction permit application. And that was projected at 21 months. And I just mentioned this because it was the newest news, but we did celebrate our final step in that CPA process on October 19th. So just recently, and again, we expect to have the construction permit in hand before the end of 2023.

(01:11:59):

You may have seen in the news the Advanced Reactor Demonstration Program. There were demonstration awards and then risk reduction awards and some others. The development of Hermes, which is in the middle or sorry on the end here, is partly funded from that program. We were awarded the Risk Reduction Award, which is a cost shared partnership with the DOE where they will provide $303 million and Kairos power will contribute $326 million. That's a total of $629 million over seven years. One of the most exciting things for me is the amount of investment that Kairos Power will be making in Tennessee, and this is prototypic of what would come in expansion to other states as well. So that's about a hundred million dollars in East Tennessee with 55 or more full-time jobs. And that's just for the Hermes demonstration reactor. We're doing this in partnership, by the way, with Oak Ridge National Lab, Idaho National Lab, EPRI, Materion Corporation, and then also the Tennessee Valley Authority.

(01:13:09):

I like to end in the last couple slides here with just a reminder that hopefully what you heard and hopefully what you take away from my presentation is everything that we do at Kairos Power is driven by our mission. We start every meeting with it, and that's to improve people's quality of life while protecting the environment. Our commitment, you can see in these four bullets here, but another big takeaway I think that's really important and interesting is that fuel pebble there on the left-hand side the size of a ping pong ball is equal to approximately four tons of coal. So the amount of energy that you can get from our reactor and the amount of jobs that our reactors can bring and the number, the total investment that we can provide is quite sizable and we prioritize and try to selectively build on brownfield sites. So what you're looking at in the bottom left-hand corner of the photos is a brownfield side of the former gaseous diffusion plant. So it was mentioned earlier, co-location with Bitcoin mining or producing, building a new plant on the site of a former coal site. These are really important things for us.

(01:14:26):

Lastly, we're not doing this alone. Early last year we created the Kairos Power Operations Manufacturing and Development Alliance that's shortened to KP-OMADA. It's actually the first modern advanced nuclear development consortium, which is comprised of leading North American utilities and generating companies that will collaborate to advance the development of our technology. So the KPFR technology, both from a licensing standpoint, manufacturing, construction, and commercialization. So we are getting the realtime insight and assistance from North America's leading nuclear companies. So we're thrilled to have them as part of this partnership and we learn a lot from them and look forward to working with

them further. If there's any questions, I'm happy to take them, but that's the conclusion of my presentation.

Rep. Keith Ammon (01:15:23):

Alright, thank you Evan, that was a great presentation and I don't know if James is still on the line, but we may have some time left for him questions as well. So questions for Kairos. You mentioned molten salt, I believe, right?

Evan Cummings - Kairos (01:15:51):

That's correct.

Rep. Keith Ammon (01:15:52):

Are there must be applications for industrial heating with that?

Evan Cummings - Kairos (01:15:58):

That's correct.

Rep. Keith Ammon (01:15:59):

Is that part of the business plan?

Evan Cummings - Kairos (01:16:02):

Yeah. Our primary goal and objective right now is to produce carbon-free electrons. But we've heard many times from customers and our partners that industrial heat is very important. It helps to decarbonize hard to decarbonize industries. And so that's certainly on our roadmap.

Rep. Keith Ammon (01:16:24):

Alright, and I think I missed the size of your reactor. The expected output,

Evan Cummings - Kairos (01:16:30):

The ultimate size of our first commercial reactor will be 140 megawatts electric. And that's per unit. So

Rep. Keith Ammon (01:16:37):

You can have multiple,

Evan Cummings - Kairos (01:16:39):

Correct. The modularity of the design helps with economies of scale, just like many other the designs out there right now. But yes, you can add reactor reactors on top of each other and share some civil structures.

Rep. Keith Ammon (01:16:54):

Alright, we have a hand raised online. Paul Gunter, would you go ahead with the question?

Paul Gunter - Beyond Nuclear (01:16:59):

Thank you. Paul Gunter Beyond Nuclear Tacoma Park. We're working with constituents in New Hampshire. So first of all, what's your maximum modular design? How many units do you project for your maximum product?

Evan Cummings - Kairos (01:17:23):

Paul, can you help me with that question? Do you mean from a,

Paul Gunter - Beyond Nuclear (01:17:26):

So are you talking about a dozen maximum units for these hundred 40, 140 megawatt reactors?

Evan Cummings - Kairos (01:17:36):

That's a great question. I think that customers will be the deciding factor there. The modularity of the design itself allows for expansion to however the site boundary allows. So it'll depend on the request from us from customers and the power demand.

Paul Gunter - Beyond Nuclear (01:17:53):

Okay, thank you. So it's open-ended.

Evan Cummings - Kairos (01:17:56):

I wouldn't say it's open-ended. Every site has its limits.

Paul Gunter - Beyond Nuclear (01:18:01):

Okay. So you mentioned that you're going to get a construction permit by the end of the year. Is that a non-nuclear construction permit?

Evan Cummings - Kairos (01:18:14):

No, that is a nuclear construction permit with the NRC.

Paul Gunter - Beyond Nuclear (01:18:17):

Thank you for that clarification. That's it.

Rep. Keith Ammon (01:18:22):

Alright, great. Thank you. We have another question. This is one of our previous speakers, Ryan. Ryan, would you go ahead with the question?

Ryan McLeod (01:18:30):

Yeah, two questions. One was just to kind of follow up on what Paul's first question related to the modularity, is there capabilities for certain aspects of the units to have shared infrastructure if you're building out multiple modules, lower certain costs and whatnot?

Evan Cummings - Kairos (01:18:49):

Yes, that's correct. Yes, that's the plan.

Ryan McLeod (01:18:51):

And then my second one is I have heard talk of Kairos exploring Canadian markets as well. I've seen Kairos on a list of reactors that are seeking licensing in Canada. Has there been any progress on engaging with any of our licensed facilities?

Evan Cummings - Kairos (01:19:11):

So you probably didn't see our name. I'm not sure yet to show me the list, but I've seen those lists. We are primarily focused on the domestic market right now in the US. A lot of that is to ensure that we are quick to construction and getting the design finalized and I would argue very, very close second is the Canadian market. We have a very, very good partnership with Bruce Power. They are best in class, they're great people and they're very engaged with our design and we meet with them often. So it's certainly something that's in our future.

Ryan McLeod (01:19:54):

Cool. Yeah, it was probably fuel related to, because I know we're doing work on Theo research. Oh, okay.

Evan Cummings - Kairos (01:19:59):

Understood.

Ryan McLeod (01:20:02):

Cool. That's great to hear your reactor. It fits in a good category between the very small and the larger s similar size.

Rep. Keith Ammon (01:20:11):

Alright. And we're focused here on New Hampshire, but we love our neighbors to the north.

Ryan McLeod (01:20:15):

Well we sell a lot of electricity for you too from Quebec. That's true Ontario. So yeah, mutually beneficial relationships. We have lots of power. It's available for you guys.

Rep. Keith Ammon (01:20:27):

That's a good point, Ryan. One thing that's interesting to me, I went to the New Hampshire Technology Alliance, had a summit recently in New Hampshire. They talked a lot about AI. The whole thing was about AI, but they talked about the energy consumption of AI to train one model is some huge amount of energy. And I know a lot of these technology companies are looking for carbon-free energy. Could you talk a little bit about the future of large compute projects? Bitcoin mining is one of 'em, but AI is another. Do you see that as a potential market for your product?

Evan Cummings - Kairos (01:21:12):

Absolutely. Right now you've got technology companies that are buying either investing in fission or fusion technologies as a bet to assist them in the future to support those demands. You've also got situations where utilities are coming up short with carbon free assets that are baseload that help with power demand needs on the data center sides. And as you mentioned, computing is increasing, so the power demand is almost to infinity it seems like. So the answer is absolutely yes. We do that through either direct engagements with those companies and understanding the best way to deploy in the right

places or in partnership with utilities that these technology companies have a large presence in demand need and working together the three of us to understand the best way to deploy the future of our technology.

Rep. Keith Ammon (01:22:18):

Alright, any other questions in the room? I have one last question. So in your slide of your alliance with other companies, you have a Southern Company and Tennessee Valley Authority and Tennessee Valley, it's vertically integrated so the rate payers can be on the hook for backstopping any risk. In a market like ours, we don't have that luxury. We're a deregulated market. We'd have to attract private capital or energy as a service business model. Could you speak to how would your business model fit into a market similar to ours?

Evan Cummings - Kairos (01:23:07):

That's a great question. My initial reaction to that is not the first reactors because they would be the most expensive and that's just natural from a learning curve standpoint. So New Hampshire being in a deregulated market, the cheapest power gets picked up first and then as demand increases, more expensive power gets added to the mix. I don't need to explain the market itself, but my intention with sharing very early on that we want to be competitive with natural gas is for that exact reason because we want to come to states like New Hampshire that we would have merchant generation risk on behalf of and be able to participate in those capacity markets and ensure that we're getting picked up at a price that's competitive for us, but also affordable for the communities.

Rep. Keith Ammon (01:24:03):

Alright, great. And Paul, do you have one last very quick question?

Paul Gunter - Beyond Nuclear (01:24:10):

Yeah, thank you. Paul. Gunter Beyond Nuclear. Could you address just briefly about when you talk about the modularity is basically up to the licensee, are your units going to be subject to environmental review and emergency planning zones beyond the site boundary?

Evan Cummings - Kairos (01:24:43):

That will depend on the final design. But the one in Tennessee, they were one in the same.

Paul Gunter - Beyond Nuclear (01:24:53):

So the environmental review and the emergency planning zone are all within the site boundary in that particular review.

Evan Cummings - Kairos (01:25:02):

Correct. For the Hermes demonstration reactor? That's correct. That is not necessarily, might not be the case for future designs, but that's what's come through with the construction permit application in Oak Ridge, Tennessee.

Paul Gunter - Beyond Nuclear (01:25:18):

Thank you.

Evan Cummings - Kairos (01:25:19):

You're welcome.

Rep. Keith Ammon (01:25:22):

Alright, very good. Thank you Evan for your presentation and your time and your patience.

Evan Cummings - Kairos (01:25:26):

Thank you for the invite. I really appreciate it.

Rep. Keith Ammon (01:25:29):

Great. And I'll probably be following up with you after we have maybe 20 minutes of just commission business. So you're welcome to stick around or drop off whatever your preference. And we have Bart Fromuth, who's a commission member. He's online. Just want to, Bart, you might have a vote or two to take here. So moving on, this is our last information gathering meeting. So the statute has this commission ending December 1st. I initially thought this would be our last meeting, but I checked with the chief of staff at the state house and I'm required to hold one last meeting, sort of like a wrap up meeting. So our first meeting was organizational, then we had regular meetings and the last meeting will be just approving these minutes from this meeting and then approving the final report. So December 1st would be the last day that I could stretch it.

(01:26:40):

It's a Friday and I have a room at the State House scheduled for that meeting. If we could all meet in the LOB. I'll get you the room number. I think I made it around one o'clock in the afternoon. So just after lunch. Does anybody, it's a month from now. Does anybody think they can't make that? And I would just need a quorum to be able to have everybody's time be worth with. So I did want to mention that.

(01:27:07):

An interesting thing that's come up in the meantime, Dartmouth has a research policy, they called a shop, a research policy shop. And it's my understanding, I don't know if this is finalized yet, but I think they're going to take our final report and do their own research projects. They're going to use students to do it if they're going to be overseen by a PhD professor following the methodology that they have in the shop. And they're going to focus on the financial aspects of trying to, what maybe federal funds may be available, what do the market conditions look like, focusing on how to finance an SMR project in the future. And so if any of you would like to be in touch with that shop with the head of that shop to sort of guide the, I know David, you were on a call earlier on that, so I think that's kind of an interesting next leg of this whole process, which is obviously going to be a multi-year investigation.

(01:28:22):

So there was an interim report created that's probably around 80% of what the final report will look like. I'm going to try to put my head down and get you guys a draft in advance of that December 1st meeting. If any of you would like to have a phone call with me to sort of give me your thoughts and ideas just to give me input, I'd be happy to do that this week and we'll try to get something completed that we can feel proud about distributing. So your options as a commission member would be to sign off on the final project after you've had your input to not sign off to abstain, or you could issue your own statement or your own addendum to the report. Things that you're concerned about that might not be in the general report. So you have some options there to sort of express your opinion about what we went through.

(01:29:28):

Are there any comments or discussion on those two things, the research shop and the final report? Does that sound good? Does that thumbs up or thumbs down?

Dan Goldner - PUC (01:29:42):

The report looked really good, so it's just what happened subsequent to that. Subsequent to that think you're updating. So for the interim report was excellent.

Rep. Keith Ammon (01:29:50):

Okay. And I'm going to try to do something that we can print out on glossy paper with nice spiral binding and make it look official. So something we can pass around. Yep. So just introduce yourself.

Hon. Dick Barry (01:30:04):

Oh, I'm sorry. Dick Barry, former state rep. Now I guess I'm beat up all the time by my kids. You won't go there. The question I have is, will this report to do a cost benefit analysis so that we are three quarters of the way into starting asking people to participate in reality.

Rep. Keith Ammon (01:30:35):

I don't know if I have the expertise to do that, but we could maybe talk about how that process might be initiated in the future if you have other ideas on,

Hon. Dick Barry (01:30:48):

I was thinking of some of the people who are supplying it and we're doing it now out there getting quotes and one person's already built it. Could you help us out with a rough level of benefit?

Rep. Keith Ammon (01:31:05):

I can certainly put out the call. So I have the contact information from everybody that's presented obviously to us so far. I can certainly put out an email to them and ask suggestions on that. Does anybody else have ideas on that?

Dan Goldner - PUC (01:31:17):

Another view with a lot of them gave us a range of dollars per megawatt hour in their presentation, which is peppered through the presentations. It's usually 60 to 80 I think. But that was, we did get that information as we went. And that might be something to capture in a summary.

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

So have a summary table of the different,

Dan Goldner - PUC (01:31:37):

Yeah, yeah, I think the range was pretty tight, but that would be interesting for people. I'm sure.

Rep. Keith Ammon (01:31:44):

It was somewhere between 80 and 120.

Dan Goldner - PUC (01:31:48):

Yeah, I remember mostly 60 to 80, but I'm sure there was wider range, but, okay.

Rep. Keith Ammon (01:31:54):

Alright. And as I mentioned the Dartmouth project, I hope they're going to focus on that aspect of it and we'll see how far we get. And David, do you think, is it possible that that work product could help the department?

David Shulock - DOE (01:32:15):

Sure. More information the better.

Rep. Keith Ammon (01:32:18):

Okay. Alright. Any other discussion on that? Alright, so we have minutes to approve from the October 10th meeting. I emailed these out about a week ago. I don't know if you've had a chance to read them. I did want to point you to one change since what I emailed out. It's on the second to the last sheet, it's in red. So there's two slight changes to Ultra Safe's presentation and that's in red on both sides. And those are the only two changes from what I sent out a week ago.

(01:33:23):

So the minutes are compiled based on the transcript of the recording and sometimes it doesn't always catch every detail. So that's why those modifications. I guess the only other change I might make that I'm just thinking of now, there's a couple of references to online webinars. I think I sent you those links. It's mentioned in section six. I may just add those links to the meeting if you guys will allow that modification. Just so they're Alright. Any discussion on the minutes or changes all. Alright. Can I box up a motion to approve the minutes for October 2nd. Okay. Cathy? Cathy makes the motion. Any second? I'll second. Second. David seconds. Okay, ready? All in favor say aye. Aye.

Bart Fromuth (01:35:12):

Aye.

Rep. Keith Ammon (01:35:14):

Any of opposed? No. Opposed. I'm just going to read the names just for the, so Cathy Beahm, David Shulock, Dan Goldner, Matthew Levander, Senator Howard Pearl, myself, and Bart Fromuth. Did I miss anybody? Alright, I think that just about wraps it up. I guess any final thoughts? This is our last meeting in this room. Any final thoughts? I know this is a lot of information for me. It's like a fire hose. I guess my general thought is there's a lot of investor money, there's a lot of environmental concerns behind this and I think some of these companies will be successful and quite a number of them may not make it across the finish line.

(01:36:12):

It's sort of like there's an exuberance in this marketplace. But I get the sense that five to 10 years from now, we may start seeing some actual projects being built. It may be in a place like Tennessee Valley or maybe in ERCOT, but energy is an issue for our region. And so this may be one area that opens up in the medium term to our market. It seems like it's not inevitable, but highly likely. So does that seem like a pretty fair assessment from what we've heard so far?

Hon. Dick Barry (01:36:59):

If I may add to it? Yeah. The Navy has had nuclear reactors for about 50 years now. They necessarily know how to keep them safe and maintained. Maybe there's some information maybe that we could take, try commercialize that level of it as we try to get into modular reactor.

Rep. Keith Ammon (01:37:28):

Yeah. And some of our presenters have made that point that you have 50 people in a submarine living right next to a nuclear power plant for months. Right. That's an indication of safety. Alright, any final thoughts before we wrap up? Just grab a mic before you start your, introduce yourself please.

Rep. Alvin See (01:37:51):

Representative Alvin See. The question I have is, has anyone identified in New Hampshire any businesses that would be primarily interested in heat rather than electricity?

Rep. Keith Ammon (01:38:03):

Yeah, that's a good question. The answer to that, I mean that's definitely one of the next areas of investigation. Does that PUC or the Department of Energy company, have we heard about large scale industrial, what that means? Yeah, I mean a cement plant. I mean there's a cement plant in Bow, right? The city of Concord has a steam heating system, right? That's a large municipal heating system. Those are the two I think I can think of. Do you have any thoughts on that, Alvin?

Rep. Alvin See (01:38:43):

No, I didn't really have any particular thoughts on that other than you mentioned Concord, but I don't think that's nearly large enough project to attract this kind of attention.

Dan Goldner - PUC (01:38:56):

Okay. The Berlin biomass, aren't they heating sidewalk in with heated with water to that? That's right.

Rep. Keith Ammon (01:39:07):

They're going ahead with that?

Dan Goldner - PUC (01:39:08):

I know that was their plan. I don't know if they're going ahead with that.

Rep. Alvin See (01:39:14):

After last week. That may change.

Rep. Keith Ammon (01:39:15):

Yeah, that may change, but certainly any large scale manufacturing that requires it, that would be an option potentially. Alright. Alright. Thank you for your time everybody. It was a fun exercise for me and I learned a lot and hopefully this keeps the ball rolling. Right? I mean, New Hampshire after Millstone closes, we may be the only nuclear generator in the whole region, so we definitely want to support. Thank you. Good. Jeff, you great.

Dan Goldner - PUC (01:39:57):

Thank you Chairman. Excellent.

Bart Fromuth (01:39:59):

Thank very, thank you very much, Keith.

Rep. Keith Ammon (01:40:02):

Thanks Bart. And we'll motion to adjourn. I'll second. Okay. Howard Pearl, seconded by Dan Goldner. And all in favor of adjourning, say aye. A. Aye. Aye. Alright. Meeting is adjourned. It is 10:43 AM Okay. Thank you to everyone line and we'll close out here.