VISASQ / COLEMAN

Nuclear Energy Market

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About Our Expert:

- Managing Director – Pelican Energy Partners LP
- Chief Financial Officer – NuScale Power [SMR] (April 2009 – February 2021)

Jay Surina has more than 30 years of experience in the Nuclear Energy space including Nuclear operations experience in the Navy as well as executive experience in the private sector. He was the first CFO at NuScale Power [SMR] from 2009 to 2021, where he raised more than $1.3 billion from strategic investors and the U.S. government. He additionally collaborated with Harvard Business School in publishing two Harvard case studies on NuScale in 2014 and 2021. Since leaving NuScale, he has been working with Pelican Energy Partners as a Partner with a mandate to invest in nuclear supply chain companies.

Moderator:

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- Founder & Managing Partner at Rosemont Legacy
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Expert Insights On:

- Overview and outlook of the Nuclear Energy market
- Why is Nuclear Energy such an important topic
- Expected drivers of demand for nuclear energy in the next decade
- Role of uranium and impact on facility operating costs
- Uranium uses and supply chain
- Role of Small Modular Reactors today and in the future
- Key players in the space and their differentiating technologies
- Key investment opportunities within the market
- Rules of thumb to use when examining the market
- Largest regulatory hurdles and risks for investors
- Safety of Nuclear Energy

Introduction

Max: Hi Jay, my name is Max and I'll be leading this call on behalf of VISASQ today. As you know, the purpose of the discussion is to learn about the nuclear energy market, including key players and trends in the industry. Before we begin, I would like to remind you that we are in no way soliciting any material nonpublic information, or any information that is confidential and related to any company or organization you are currently or have ever been affiliated with. If you believe the answer to any question involves any material nonpublic information, please tell me right away and I'll take us in a different direction. And with that, any questions before we begin?

Jay: Nope, that's clear.

Max: Perfect. So, to kick us off here, Jay, could you please provide a short overview of your background and experience in the nuclear energy space?

Jay: Sure. So, I am a nuclear trained engineer, having graduated from the U.S. Naval Academy in the mid 1980s. Spent four years on two different nuclear submarines, so I learned the operations of nuclear power while I was in the Navy. After leaving the Navy, I got an MBA and I've been working for the past 30 years in the energy industry, mostly the electricity industry, and of which for more than half of that time I've focused specifically on the nuclear part of the power industry. I was the first CFO at NuScale Power from 2009 to 2021, and after leaving NuScale I've been working with Pelican Energy Partners where I'm a partner at the fund that has a mandate to invest in nuclear supply chain companies.

Max: Got it, perfect. So with that, Jay, I'd like to start with an overview of the topic and a bit of market outlook. So, can we start from the top, just what does nuclear energy even mean?

Overview & Market Outlook

Jay: I mean, it's interesting that you ask that because I think it means different things to different people, although generally most people accept nuclear energy to mean electricity coming from a fission reactor around the world. I do believe that once we get to having fusion that nuclear energy will encompass fusion power as well, we're just not there yet. So, generally nuclear energy means the electricity made from a nuclear power unit, and in some cases also the heat, the process heat that comes from a nuclear power unit that can do things besides make electricity.

Max: Got it. So, we're talking about fission today.

Jay: Yes.

Max: For all intents and purposes-

Jay: Today we're talking only-

Max: Got it.

Jay: Hopefully someday We're talking about something fusion, but we're just not there yet.

Max: And so, fission is the primary way nuclear energy is created, is that right?

Overview & Market Outlook

Jay:

Yes. So, the difference between fission and fusion is pretty simple. So, fission is taking really big atoms like a uranium atom, which is U-235, so 235 neutrons and protons, and splitting that to create heat, which the heat being the energy that comes out. Fusion is the opposite, it's taking small molecules, like hydrogen and helium, the smallest, and putting those together, and when you fuse them together it creates energy.

Fusion is what powers the sun, we have not figured out how to do that here on earth yet to make large amounts of electricity. The Navy first had a nuclear power plant on one of its submarines in 1955, so it's been 70 years that we've been doing nuclear power.

Max:

Got it. And it seems as though nuclear energy is becoming an important topic of discussion, it's coming up more frequently in the news. Why is that? What's happening that this is coming up?

Jay:

Yeah, it's pretty amazing how nuclear has, in the recent past, turned from what many believed it to be a dirty, bad industry that frankly some people think nuclear energy kills people, although it doesn't. From that, to where we are today where it seems to be generally embraced as an environmentally sound, sustainable concept, and largely that's happened in the last ... And what's driving that, the main thing that's driving that is climate change. So before, as climate change has become a bigger issue, I mean, earlier in my career, so 20, 25 years ago when I was doing power plant development, nobody valued nuclear energy because it was just a higher cost way of creating electricity compared to burning fossil fuels.

When you fast-forward to today, we're trying to get away from burning fossil fuels, and the only source of carbon-free base load generation available at scale today is nuclear fission. So with that realization, as we try to decarbonize the world economy, and nuclear being the reliable technology that's available today, that's turned people towards looking at nuclear energy more and more. And it's actually gone from being a industry that was generally hated by environmentalists, to an industry that now is being embraced as maybe a big part of the answer to climate change.

Max:

Awesome. You said base load there, can you just elaborate on what exactly you mean by that?

Overview & Market Outlook

Jay: Yeah, so that's an important point. So, base load means 24/7, reliable power. So, a power plant that can produce power under all conditions for 24/7, as opposed to other technologies that are intermittent. So, most of the renewable technologies are intermittent, so wind and solar, they produce carbon-free power, they do not produce carbon-free base load power because the reliability is not there.

Max: Got it. And what, in your opinion, are going to be the expected drivers of demand for nuclear energy in the next decade?

Jay: So, we're starting to see a pretty broad demand for nuclear energy. The one that has most recently in the last year or so come to the forefront is in the powering of data centers for AI. In the last year or so there's become a realization that we're going to need a lot of power for AI data centers, and AI data centers need base load power. So, other intermittent sources of power that are carbon-free, like renewables, wind and solar, cannot reliably power data centers. And that's caused this demand for nuclear, which is leading to increases where people are willing to pay three to four times the commodity market price for electricity for nuclear, and those people are the tech companies, the contracts that are being signed because they need reliable and they want carbon-free power. So, that's been a significant driver in the last year or so with that realization.

But beyond that, we're trying to electrify our economy and get away from burning fossil fuels, and you need carbon-free base load power to do that. So, that's another driver for electricity demand. And with climate change being such an issue, we have been, in the United States, shutting down coal plants for decades. So, coal is becoming less of a driver of electricity prices and electricity supply, and we've even gotten to the point of not wanting to build as much natural gas, even though natural gas is less carbon- intensive than coal is, it still emits fossil fuels. So, we've gotten this perfect storm, not just the United States but in other places around the world, where we are shutting down carbon-intensive electricity generation and have been doing that for a while. We've been placing that with intermittent wind and solar generation, which does not provide the reliability that nuclear does, and now all of a sudden over the past few years the world is waking up to the idea that you not just need carbon-free power, but you need carbon-free base load power, and that's also driving this demand that we're seeing today for nuclear power.

Overview & Market Outlook

Max:

Got it, super helpful. Thank you, Jay. Moving on to the role of uranium, it feels like we have to touch upon this briefly to make sure we level set for everybody. So, what is the role of uranium in nuclear energy?

Jay:

Well, clearly uranium does, the uranium commodity has a role in nuclear energy, and we have seen the uranium markets be fairly volatile, went up a lot in the past couple of years and recently have been quite volatile. And the uranium market is a component of nuclear power, but from an economic perspective the uranium commodity that goes into producing electricity is well short of 10% of the operating costs of a nuclear power plant. So, uranium is one of the few ways that you can be a part of the nuclear ecosystem from an investment perspective right now, because there is a uranium market and there are companies that are publicly traded that you can stake a position in uranium, and there is a perceived supply demand balance right now in the uranium markets that's been driving some of this volatility. But the reality is there is plenty of uranium in the ground.

The issue is as we need more uranium, if we continue to build reactors, which it looks like we're going to do, is getting that uranium out of the ground and it takes a long time to bring up the mining capacity to do that. And then, there are other geopolitical problems associated with getting uranium from places like Russia, and unstable places where the U.S. is trying to have domestic supplies so we're not beholden to other countries for that, that's added to the mix as well. All that to say uranium is an important part of the nuclear power equation, but from an economic standpoint it is not a huge factor within nuclear power.

Max:

Got it, that makes sense. So, 10% of the operating costs of a nuclear energy facility is uranium, that's really helpful. Can you explain where exactly uranium fits into the fission process?

Overview & Market Outlook

Jay: Yes. So, like a fossil fuel power plant, or say a coal-fired plant, or a natural gas-fired plant, basically the way a power plant works is you have something that boils water, you have a fuel that boils water, and then you have a turbine and the system to take that water that's turned into steam and turn that into electricity. So, for natural gas-fired plants, combined cycle units, that is you burn natural gas, you boil the water, you create electricity from that. Same for a coal plant. In a nuclear power plant it's very similar, but your fuel is uranium-235, so that's a little different. You're not combusting uranium-235, you're having a fission reaction that creates heat that then boils the water and creates electricity. So, the uranium component and the uranium supply chain is a whole separate supply chain that's part of the value chain for creating electricity that comes from a nuclear power plant, but it's a whole separate ecosystem that has got a lot of factors in it.

Like we were talking about economics and supply-demand about the uranium commodity itself that you dig out of the ground, but then there are several steps before you turn that uranium commodity, it needs to be enriched, because most of the uranium that you get out of the ground cannot be put into a nuclear power plant. So, most of the uranium that you get out of the ground is stable and it's uranium-238, less than 1% of the uranium that comes out of the ground is something that you can put into a reactor and cause heat, and that's the U-235. And so, there's this process from mining the uranium to then changing it into something that you can actually put into a fuel rod in a nuclear power plant, and that has its own separate ecosystem and separate set of supply chain companies that deal with that issue. And essentially the nuclear power plant and the operator, all they really care about is getting a fuel rod that has enough uranium-235 in it to create the heat to then boil the water and create electricity from.

Max: Got it, that's super helpful. Some really interesting tidbits there. So just to be clear, it is every single fission-based nuclear energy facilities require uranium-238.

Jay: They require U-235-

Max: U-235, sorry.

Overview & Market Outlook

Jay:

... it's just they happen to, when you mine uranium you get U-238, a lot of U-238 and a tiny bit of U-235, and all of the current concepts including all of the new concepts, so the reactors that we have around the world today are mostly what are called light water reactors, and they all use uranium-235 in fuel rods to create ... And that's where the fission comes from. It's the U-235 that gets the large atom that gets broken into pieces when you fission it, when you hit a neutron with it, that creates the heat. So, that's the existing way that we do things today are largely using fuel rods. Even the new concepts that we hear a lot about that haven't come to market yet, so new advanced reactors and small modular reactors, they all use uranium-235 currently, they just use it in a different way to get to the fission reaction.

There are thoughts about using other fuels. You can use thorium, you can use plutonium, there's other large atoms that are fissionable in reactors. It's just that the existing supply chain that is 70 years old for U-235 is pretty well entrenched and it's likely that we're going to need to use that supply chain, because it's very, very expensive to establish another fuel supply.

Max:

Got it, that makes sense. And is the nuclear energy market the only end market for uranium? Just to understand how connected both industries are, and the dynamics of this, and how sensitive nuclear energy market is to those supply chain dynamics.

Jay:

Yes. So yes, there really is no other practical use for uranium-235 coming from uranium-238 other than to put it into a reactor and create electricity from it.

Max:

Where does most of the uranium come from that feeds the nuclear energy market?

Overview & Market Outlook

Jay: So, the countries that have the largest uranium supplies are Kazakhstan, Canada, and then the third one that's quite a precipitous drop-off is Canada. And amongst those three countries, they have about two thirds of the uranium supply from around the world. Then the rest of it's distributed around, there's some countries that have significant supply but much smaller percentages. There's countries in Africa, the U.S. has some ability to mine uranium as well. Uranium is found in every continent, or is mined in every continent except Antarctica currently. And I'm pretty sure there's probably uranium in Antarctica, we just can't get to it.

Max: Got it. Sorry, you said Kazakhstan, Canada, and what was the third country?

Jay: Australia.

Max: Australia, understood. Well, it doesn't sound like there's a ton of geopolitical risk for Western economies and Western based companies, or is that my misunderstanding?

Jay: Well, so the supply chain, there is some. So, the supply chain goes beyond just the mining of the uranium, then you need to do all these other things before you can actually put it into a reactor. So, in the U.S. we're talking about burning a higher enriched uranium. So, in most reactors around the world, the enrichment, so how much uranium-235 there is in a fuel rod compared to uranium-238 is less than 5%.

So, when you're in a fuel rod in a nuclear power plant today in the U.S., that fuel rod is primarily uranium-238, 95%, and 5% or less, U-235. We're talking about allowing the reactors to burn what's now called LEU+, or low enriched uranium plus, which is greater than 5%, all the way up to a product that's now called HALEU, high assay low enriched uranium, which is up to 20% U-235.

And the reason why we don't typically go to enrichments higher than that, because you could get more power and more fission with the more U-235 you have in your fuel, but there are concerns around U-235 because you can make a nuclear weapon out of it. So, the governments around the world have basically come to a consensus that it's okay to have up to 20% U-235 because you need a lot higher enrichment to build a weapon out of that. So, there's a lot of government oversight, both from the U.S. government and others, to make sure that we don't allow enough enriched uranium out into the marketplace to allow people to make nuclear bombs, which is a significant concern obviously. So, I guess your answer to the question previously, what can you use uranium for? I didn't say for nuclear weapons, but that is another use case for nuclear weapons. Most all of uranium-235 goes into making nuclear power.

Technological Innovation

Max: Understood, that's helpful. And how important are giant companies like EDF and Rosatom? You talk a little bit about their impact on supply chain?

Jay: Yeah, so they're very important. So, like we were talking about on the supply chain for the uranium sides, so for the fuel rods, you have all the mining companies and they're in different countries. You then have the companies that do enrichment and a conversion, conversion means you can't take the yellow caked uranium that comes out of the mine and enrich it easily until you turn it into something else, because the way we enrich uranium make the higher percentages of U-235 is it needs to be in a gaseous form. And so, the uranium that comes out of the ground needs to be converted into uranium hexafluoride, and then uranium hexafluoride gets enriched. And so, there's a company that does what's called conversion, turns the uranium that comes out of a mine, there are several large companies that convert that in the uranium hexafluoride. Uranium hexafluoride then goes to an enrichment company, of which there are several large companies around the world that do that.

And those enrichment companies turn the enriched uranium hexafluoride back into a solid, so it can get moved to a company that can then turn that into fuel rods. And companies like EDF and Rosatom, they want to have domestic fuel for their own reactors. So for EDF, it's for the French reactors. For Rosatom, it's for Russian reactors. Even though the uranium is not coming from Russia, Rosatom and EDF need to have, for their own domestic purposes, they need to have some control over the fuel rods so they are brokers of the fuel rods, along with other western companies like GE Vernova is big into nuclear fuel, Westinghouse is big into nuclear fuel, the Koreans have a nuclear fuel company.

So, the whole supply of U-235 has this ecosystem around it that's very complex and that gets into statecraft because of domestic needs for the countries like Russia, U.S., France, the Japanese, the South Koreans that have a lot of nuclear power, and to some extent now the Chinese as well, need to have some control over that supply chain so that they can ensure that they don't ever get shut out of not being able to run the reactors.

Max: Got it, super helpful. That's a great overview of the role of uranium, thank you. Moving on to technological innovation in the space, Jay, and you alluded to this term before and I think it's a great place to start. SMRs, small modular reactors, what are they? What role do they play today? What role do you think they'll play in the future?

Technological Innovation

Jay:

So, SMR stands for small modular reactor. So, the first companies that started doing small modular reactors, so I worked for one of them at NuScale, and NuScale got started in 2007. So, the first new startups that thought about how to do nuclear power differently started in that 2000 to 2010 timeframe, and some of them have developed to the point where they are ... We have a couple of public companies, NuScale, Oklo, which is a little bit of a different product, and are getting to the point where those technologies are ready to deploy. And some of those technologies have contracts to build facilities, and there's lots of different concepts out there. So stepping back a bit, so why do we need a small module reactor or these new advanced reactors compared to the traditional nuclear industry?

So the traditional nuclear industry, which came about out of the needs of the U.S. Nuclear Navy, is built around light water reactors. So, those are reactors that use uranium-235 and water as the fluid that moves the energy around in a system. And there's virtually every reactor that's currently existing in the world, and there are about 440 of them, are all light water technologies and they tend to be very large reactors, because the economics of those are that the bigger the scale that you have, the cheaper the electricity that comes out.

Now these new technologies, small modular reactors and advanced reactors, and people have different definitions of what a small modular reactor is and what an advanced reactor is, and generally they are just new technologies that are trying to break the paradigm of needing to have these very big, light water nuclear power plants that are huge infrastructure projects that cost tens of billions of dollars to put up, breaking that paradigm so that you can bring nuclear power to places that don't have the ability to have a, say $30 billion infrastructure project. These new small modular reactor and advanced reactor companies are trying to basically in some sense democratize nuclear power so that it can be done in smaller bite sizes, and at costs that hopefully are going to be cheaper than the older way of delivering nuclear power. So, that's the concept behind why it's being done.

A small modular reactor is a, instead of the units that are done now today in nuclear power, the large units which tend to be 1,000 megawatts to 1,400 megawatts, or a gigawatt to 1.4 gigawatts in size per unit, and cost $10 billion plus to put one of those up, these small modular reactors and advanced reactors tend to be in bite sizes as small as, for the micro-reactors, less than five megawatts, to being able to construct a larger plant that could be a gigawatt or 1,000 megawatts by ganging together modules that are factory- made 80 megawatts, 150 megawatts, each concept's a little different.

Technological Innovation

Jay: But they're all trying to take advantage of what we would call the economies of small, which is let's, instead of stick building these very large complex infrastructure projects, let's take the manufacturing into a manufacturing facility where you can control the costs and then deploy that, basically not have as much construction for the new concepts on site and lower the costs, and therefore make it cheaper and also in smaller bite sizes so that we can have more nuclear power around the world to a broader swath of folks. That's the concept.

Max: That's interesting, Jay. So, it sounds like the reason for this innovation is to solve how complex and large scale precedents of the technology are. I didn't hear you talk about the transmission grid, for example, because it seems like that would be one advantage of having SMRs all over the place as opposed to one central massive location that then the electricity needs to get transmitted. I guess, are there other advantages or other reasons why this kind of innovation happened, or it's really just to get around the fact that it's so expensive, and tedious, and time-consuming to build a large scale facility?

Jay: Yes, there are multiple factors. The idea that the existing reactors have gotten so large and complex is, in my view the driving reason why we were doing things at my old company at NuScale, it was one of the driving reasons, and the economics of having to build everly increasingly large reactors. But there are significant other factors that make small modular reactors and these advanced reactors more appealing. So, one of them is transmission. So, an appeal of renewables is that you can distribute power around in places that you might not be consuming the electricity, but then you need transmission to get the power to where you need it to go. Small modular reactors, you can build a power plant, I mean, technically you could build a small modular reactor in New York City where you really need a lot of electricity supply.

The demand supply in cities is such that you have to basically import electricity into the cities because the supply of electricity, which is a local commodity, you're not going to build a power plant in most cities.

Technological Innovation

Jay:

And up to this point, it's been impossible to build. You couldn't site a nuclear power plant in cities. And I'm not saying that we are going to site small modular reactors in New York City or in Chicago, but the mere reality that you could actually do it now is significant, because then you don't need to build transmission. And transmission is, when we're talking about nuclear power and the generation side of consuming electricity, the generation side of our electricity build tends to be only about a third of the cost of when we turn our lights off. The other two-thirds is transmission and distribution, and transmission, I tell people a lot, it's really hard to build a nuclear power plant, to get a power plant sited, and it takes a long time and there's a lot of opposition to it. In my opinion, the only thing harder than to site and build a nuclear power plant, it's a site transmission. So, if you can find technologies when you don't need to build gigawatts worth of transmission to move the electricity around, that is also very good for the economics of getting electricity to the people.

Max:

Yeah, that's helpful. So, you mentioned NuScale, obviously you're an alma mater of there. We also have Oklo and TerraPower. Can you just touch a little bit on what these innovative companies are up to? And then, yeah.

Jay:

Yeah. So it's shocking to me, but when we started at NuScale we were pretty much in the woods without anybody around us. Nobody thought it was a good idea what we were trying to do. Now there are, in the U.S. and Canada, there are more than 100 companies trying to commercialize some new nuclear technology, and they all have a different take on it. And everybody will tell you about how great their technology is, and the reality is the world doesn't need 100 new nuclear technologies, and the world's not going to ever purchase from 100 different technology vendors. In the end, the market for new nuclear capacity is going to come down to at most a half a dozen players. So, you have a lot of these new concepts, and the best technology from a technology standpoint may not be the winner.

Really the winners are going to be the ones that can actually raise the large amounts of capital, because to bring a new nuclear technology to market at the scale of an SMR is well over a billion dollars, and these startup companies have difficulty raising that capital. We had difficulty raising that capital at NuScale. It's very hard to do that when you talk to an investor and say, "Hey, I have this new concept. I may be able to build it in 15 years after I go through the toughest regulator in the world, the NRC, and spend hundreds of millions of dollars with that," it's not a really great investment concept for most.

Technological Innovation

Jay:

And so, we have lots of these new technologies, you named a few of them, and the ones that you named are the ones that appear to be the furthest along and could be the winners.

So those in my view are TerraPower, NuScale, GE Hitachi, Oklo, Last Energy, and there are a few more. And what differentiates all of those technologies is, well, they all have a little different take. Some are doing replacements for large power plants, some are just trying to do small distributed generation at 5 megawatts, or 10 megawatts, and those markets are different. So, there's differences in technology, but what really makes a difference is can the management teams of these companies manage the process to get the commercialization and raise the capital? And those companies that I mentioned have shown that they are able to at least raise the capital to make their concept be viable, even as none of them have yet gotten to commercialization. Some of them are getting close, we have not built any of these technologies yet, and it will be several years before we do build any of them.

And before we know whether they work, and when I say work, it doesn't mean that they're not going to work technically, this is all fissioned, these technologies, some of these technologies have been around for decades. They will work technically, the issue is will they work economically and operate for long periods of time as the existing fleet has done, and how will all that shake out?

Max:

Got it. But generally speaking, all of the startups you mentioned are chasing the same thing, which is SMRs that can be delivered all over the place in a variety of environments, and producible at scale.

Jay:

Yes, although there are different markets. So, when you determine SMR, a medium-sized technology. And we have the very large, the gigawatts and greater, that's a separate market. We have the very small, the micro reactors. So, Oklo is a micro reactor, so it's a little different than the SMR technologies, and they're each going for a little different market, and those markets each have a different price point and each have a different customer base. And it's hard to characterize all of them as one because they're not, although most people don't understand that there's a lot of differences amongst those 100 different companies that are trying to commercialize technologies in what they're trying to do and what their strategies are in coming to market.

Investment Opportunities & Risk

Max: Got it, Super helpful. Jay, I'd like to move on to our final section here, so investment risks and opportunities. What do you think are the biggest investment opportunities within nuclear energy today?

Jay: I'm pretty bullish on the nuclear industry, I've been in it for a while so maybe I'm a little biased. The investment environment for companies that are in the nuclear ecosystem has gotten much greater over the last few years, and a lot of that's because of what we were talking about earlier, there seems to be this realization generally worldwide that we need nuclear power and we don't want to shut down any reactors, we want to build a lot more. So, that creates a lot of opportunities. Now, there are obviously still a lot of risks associated with that. The building of new technologies, and even building existing technologies in nuclear, is always a very risky endeavor because these are complex projects to build, and then you want those assets to last for 40 plus years, which the existing fleet has.

And so, picking what are the best opportunities against all of the many risks? There's political risk in the industry, there's political risk within countries around nuclear power, it's quite a mix of both opportunities and risks. But at the moment it seems to be that people are seeing that the risks are being outweighed by those opportunities. So, where can you invest in nuclear? Shockingly, it's a hard thing to invest in nuclear right now. There are only supply chain companies, but there aren't that many of them. So you have Westinghouse, GE Vernova, BWXT, you have some very large companies that are in the industry today that are already publicly traded. So, you can try to invest on the public markets, you can invest in the miners that we talked about, uranium, and many of those are publicly traded.

And there are ETFs trading just uranium, so if you want to play the uranium market, but that's a separate market from nuclear power overall in the whole nuclear industry. So, at the moment generally there's not a whole lot of way ... You have to be creative to create the opportunities at the moment to invest in nuclear, and that's starting to change as it appears that larger money sources are warming to the need for nuclear power and wanting to put their money into that. But at the moment it's hard to invest purely in the nuclear industry. But even in the past few years that has started to change where you can start seeing things. So I, for example, I work in private equity, and we have a vehicle to invest in nuclear from. That didn't exist a couple of years ago.

Max: Yeah. No, that's interesting.

Investment Opportunities & Risk

Jay: So, there's only so capital companies you can invest in as well. So, it's hard.

Max: So Jay, can you help me understand what are some rules of thumb to look for, for folks that don't have the same experience in the industry? Let me give you some just examples to help you recognize what I mean, but are there rules of thumb around the time required to build, to get to market shouldn't be longer than X years? Acknowledging that it's long but shouldn't be longer than this. You typically need a scale in terms of order volume, or capacity or what have you to reach breakeven, which is this, breakeven is expected within X time period, or things like you always want to see long-term PPAs in place before X happens and it's like a red flag if you don't see those things, or if you see things move across a different timeline. Are there some generalizable rules of thumb that you can point us to as it relates to evaluating projects and opportunities?

Jay: Well, I'd like to say that there are a few that are easily ... I mean, there are, but they're hard to understand what they all mean at the moment. So yeah, it would be people look at the technologies and they say, "Well, how long is it going to take for this to happen?" The problem is nobody knows because with these new technologies, none of these companies have come to market yet. They're not commercialized yet.

And there's generally a lack of understanding in the investment community about the nuclear industry, because for the longest time nobody wanted to invest in nuclear industry because it was not a great investment.

So as far as thumb rules, all I could say is what most always go back to is building a cash flow model and trying to take all of the risks associated with it, and there are many factors when you look at investing into new technology, and what those returns might look like. And at the moment it's really hard to model all of this out and come to a reasonable certainty of what you think your returns might be. And therefore, these investments are frankly pretty risky at the moment, we don't know what the outcomes would be because we haven't really done this a whole lot. And when we have, like the last nuclear projects that have been built in the Western world, which are large plants, have not gone well. So, we built two reactors in the United States here in Georgia, they were supposed to take six years and that's the good thumb rule that from the time you start conceiving of your nuclear project to when it actually gets built, five, six years is a good timeframe.

Investment Opportunities & Risk

Jay: Those projects took 13, 14 years to get done, and cost three times as much as what the vendor originally said they were going to cost. And the same thing happened with the French building, they built a unit in Finland and they're building a unit in France. The one in France is still not on, and it started construction prior to 2010. The one in Finland is on. So, the problem with trying to model all this out and predict what the real factors are is we don't have a lot of precedent to understand exactly how it all works that has been successful. And I know that's not a real answer, but it's the reality in the nuclear industry. Hopefully in 10 years, when some of these things actually start getting built, we can make better assessments, but it's hard right now to figure all of that out.

Max: Yeah, that's helpful. So, I want to talk about regulation. What are the biggest hurdles? Where are these projects and challenger, and innovative companies with regards to the regulatory process? And then, maybe you can just summarize the biggest risks that make that discounted cash flow analysis difficult for investors. So, those are two big topics that I'd love to touch on before we wrap here.

Jay: Okay. So, I'll quickly talk about regulation because it is obviously, it's one of the risks as well that has to be taken into account in investing. So, I'd like to tell you that it's clear what's going on with regulation in the United States and around the world. The Nuclear Regulatory Commission has recently had its mission statement changed by Congress, because prior to the ADVANCE Act, which came out last year, the basic mission of the Nuclear Regulatory Commission was safety at all costs. And that has slowed innovation and made the regulatory process very expensive, very long, and to the point that some companies won't even try to go through the Nuclear Regulatory Commission, even if they're U.S. based technology, they will go someplace else around the world to try to get their plant built because it's very hard in the U.S.

That seems to be changing a little bit. The U.S. government realizes that if it continues to be as hard from a regulatory perspective to bring a new technology to market and build a new nuclear power plant, that people are simply going to go elsewhere and the U.S. is going to lose out on the ability to commercialize some of these technologies. So, going on to what are the main risk drivers for building a new nuclear project, certainly one of them is the uncertain regulatory process. And that uncertainty does not appear like it's going to go away in the next few years. Yet we're talking about having projects like TerraPower tells everybody that they're going to have a project up by 2030. NuScale, if they had a customer, which at the moment they don't, would probably say they can have a plant built by 2029 or 2030. X-energy was saying that they'd like to have a plant built by 2030.

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Jay:

But all that is very speculative from a regulatory standpoint because it's not clear that the U.S. Nuclear Regulatory Commission can move quick enough to do everything necessary for all of those technologies to be built. So, regulation is a significant risk factor in all of this. Because of that, the other big risk factors are how long does it take to, from the time you start doing something to the time you actually have a functioning power plant? And history has shown that it's not five or six years, as it probably should be, that it is well over a decade. And that's really hard from an equity perspective, because the cash flows to build a power plant, once you start constructing a power plant, these are very capital intensive assets and you have to put your money in up front to get them built before you can see any return. So, that's a significant risk, how long does it take to actually bring these technologies to market and build a power plant?

And with that timing, the other risks are interest rate risk is a significant risk for the nuclear industry. When interest rates are low, because you're talking about every very capital intensive asset of which capital costs and interest rate, all of the costs associated with capital are a very significant part of the overall cost of the electricity that comes out of a nuclear power plant. So, when interest rates were hovering at 0%, things looked a lot different than when we have an interest rate environment where your treasury is 4 or 5, possibly 6%. So, that's a significant risk, and because of the extended time frames of doing all of this it's hard to predict what interest rates are going to be when you're actually building that nuclear power plant, and how much capital it's going to take you. So, if I were to talk about three big risks associated with all of these projects, those would be the big three, time frames, interest rate risk associated with the capital, and the regulatory risk associated with building new nuclear.

Max:

Super helpful, that was great. And then Jay, we're running out of time here but I want to get your thoughts on a final thing, things like safety, and then recycling and waste, we haven't touched on those. Is it safe to assume that the industry has sorted those things out, or are there unanswered questions that remain as we think about the future of the nuclear energy market?

Jay:

Well, in a nutshell there will always be unanswered questions around nuclear power because of the catastrophic risk when you have a problem with nuclear power, which we've seen come to roost a couple ... Fukushima, and the Russians with Chernobyl.

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Jay:

So, there will always be questions around safety, and there will always be questions around spent nuclear fuel and also proliferation of digging up new nuclear fuel. I don't get asked those questions any longer by investors as much as I did four or five years ago.

Most investors, when I talked to them four or five years ago, the first thing they would ask about is, "Aren't these plants unsafe? And what are we going to do with all that spent nuclear fuel, and isn't that a huge problem?" And I would give the same answer I give today, which is when those issues come up, which they don't come up as often, or some calls I don't get asked that at all any longer, and it's because generally the nuclear industry is very safe. Even the existing nuclear industry is very safe.

No one has died in the United States, or even Fukushima, nobody died in Fukushima from the natural disaster that created the event at Fukushima. Nuclear power is the safest generating technology bar none that's available to us. And so, we can talk about making it more safe, but it's really noise. And with respect to fuel, yes, we have nuclear waste that's difficult to deal with, mostly that's an economic problem and we're not talking about large volumes of waste. It is not a huge amount, it is not a big problem, but the perception of it is that it is a big problem. And people are getting past the ideas of safety and nuclear waste being these big game-changing problems in the nuclear industry that's going to keep it from going forward, they simply are not that big of issues.

Max:

Awesome, I think that's a great way to wrap. Jay, thank you so much for your time. This is exactly the kind of insight we were looking for. We're fortunate to have been able to speak to someone with your experience, so thank you for sharing your time with us.

Jay:

Well, thank you. I really appreciate doing these types of things, and I always love talking about nuclear power. It's a passion for me.

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Max: All right, well thank you so much. Enjoy the rest of your evening, and we'll be in touch.

Jay: Okay, bye.

Alex: Thank you both, have a great night.

Jay: Okay, bye.