

The Rational Optimist Podcast

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Carl Perez: You'll notice that there is a skewed business model in the United States, just because the way that waste management works is you pull the spent fuel out of your reactor, you put it in a pool, you let it cool for a handful of years, and then...

Typically in France, you don't have any dry storage. Everything's in pools. Pull it out of the pool, send it to La Hague. La Hague, it's received, then stored in pools, and then it's recycled. Whereas in the United States, we were supposed to send it all to Yucca Mountain. And in 1998, they did not start fulfilling that service, the DOE, and it's only later on that they realized that they were pretty far from delivering that service.

So dry cask storage systems in the United States only exist because the DOE failed to get Yucca Mountain going. So what's happening is utilities claim that DOE is in breach of contract, which makes perfect sense. So as a result, all the dry storage casks, like where all the dry storage costs are actually reimbursed by the Department of Energy.

So in the United States, the business model for waste management services needs to work in conjunction with fuel procurement. You cannot just recycle and provide a recycling fee and have that be competitive with waste management today.

However, after 2014, the Department of Energy basically revised the standard contract, which basically stated that every utility was to pay a mill of a dollar per kilowatt hour generated. And they reneged on that and said, "well, from now on, we're only going to take title or ownership of your spent fuel." I think it's like 20 years after the first discharge from the core as like the earliest time at which DOE can take title to it. Naturally, it'll probably only take title to the material once there's a repository. So it's the reason why they also added a backstop, and at latest, 10 years after license termination.

So what does that mean in real terms? If you're Vogtle—that started up in 2023 and 2024, or let's say 2024 and 2025—DOE can claim title in 2094. So all the costs that you have to bear from dry storage casks are now going to be on your balance sheet. And so if you're an advanced reactor vendor planning to build a new reactor, you're in for bit of a surprise when you're going to see the cost of waste management.

Now, a lot of individuals are correct in saying that waste storage systems are pretty well understood, and you can use multiple layers or a cask and a cask when it comes to some of the advanced reactor fuel. But frankly what's a little difficult is going to be convincing the NRC that, hey, this type of fuel that's been that has had this type of burn-up can be safely stored. You still need to show that data. So even if we all know it to be true, there's gonna be a little bit of an encumbrance there.

But I think that the big takeaway is that the DOE is no longer going to be reimbursing these costs on an annual basis. And if you're an advanced reactor company that's also planning to be a utility, I think the last thing that you want to be doing is building out an entire legal team internally to sue the DOE repeatedly and recover a portion of the cost.

So I think for the micro reactors, you're not going to be dealing with as large volumes. But with, and I don't want to come across as anti-nuclear, you know. I'm being the deliverer of bad news, but I'm just kind of anticipating the tsunami that's coming that no one's really thinking about because everyone's just focused on deploying their reactor and a little less so on what happens the moment we turn it on.

Stephen McBride: I haven't—maybe besides Oklo, we can get to them in a moment—I haven't heard any other SMR startup talk about their nuclear waste strategy. What is the playbook? Or is it kind of like everyone's just focused on turning the reactor on first?

Carl: I think I have every financial incentive to say that nuclear waste is a safety problem. But it really isn't. It's a financial problem, it's a social problem, a political, but it's not...like no one has ever died from spent nuclear fuel, you know, or has ever been really exposed to it. I mean, I literally spent several days on top of it. And my biggest radiation dose was from the airplane going back to New York.

So, you know, it's not really a safety issue more than it is a cost issue. Now, that's the reason why I think a lot of folks are trying to squash that issue and just say that it isn't a major problem. Or, you know, as long as you don't state out loud that it's a problem, then, you know, it's kind of the ostrich mentality. So, you know, it's optimism, right?

But I think that they're just so focused on the advanced reactor deployment in the first place that the waste management is not being seen as a priority. It's almost as if it's...because we're going to be making so much money deploying these systems, we'll be able to handle that after. And I think, I think at the end of the day, no one's going to build a reactor or license a reactor without a proper waste management plan, stipulated by the NRC.

What I do think is that products can be delayed because they haven't done enough work in that domain. You're hearing about reactors that would literally just like the core, they would replace the core in its entirety. There's quite a logistic to that, right? If you're a microreactor and you're replacing the entire core with the fuel that's inside, that same core went critical with the fuel that's inside. So then you gotta move it around, and you make sure that it's not gonna be exposed to any high temperature.

And I'll tell you what, spent fuel is hot. You know? Even when you load it into a dry cask 15 years after it's been cooled, I mean, the transport cask that you use as a sleeve to transfer it from the pool into an MPC into the overpack and the dry cask storage area, like if you put your hand around it, it's hot.

Stephen: What material are dry casks made of? And I almost envisioned them like a barrel of whiskey...like can you buy them in different sizes? Or just talk me through the actual economics of the whole industry.

Carl: Yeah, I mean, there are so many canisters and casks. You'd be surprised. And some of them are dual-purpose. Some of them are for storage and for transport. Some of them are only for transport. For the most part, it's really steel, stainless steel, then you have the overpacks that you see like, you know, parked outside of nuclear power plants on those images in the US. And that's basically concrete and steel.

Stephen: So I think most people still hear “nuclear waste” and they scream in horror. Is it just that the technology has gotten so good and the storage systems have gotten so good that, as you said, nobody's ever been harmed from them? Why do people still have this perception? Is it just pure Hollywood?

Carl: I mean, it is radioactive for over 100,000 years, right? So I can see how cross-generational challenges may seem like existential threats. I can see how people will be like, oh, well, this material is radioactive for 100,000 years. Who knows where humanity is going to be in 50,000 years? But one thing's for sure is that the nuclear waste will still be here. So I think the length of the issue is what scares people.

And then the other thing is, I also think that there's just a lack of knowledge around radiation. You weren't surprised, but I think a lot of people would be surprised to know that standing on top of a reactor and a spent fuel pool, you know, and my worst dose was that one-hour flight back to New York. And I probably got worse of a dose standing next to a red light in New York City with a bunch of cars and all their exhaust pipes.

So I think if people really had, the general public had a greater appreciation of what radioactivity is, what levels are dangerous, what is, because we're under the impression kind of that, and this may be a controversial take, right? Like, you know how everyone was like, "carbon is bad. Carbon is just bad." And so it got to the point where you had engineers, you know, for electrifying that said, "I don't want to use a carbon anode because it's to be a carbon waste form." It's like, OK, we don't have to take it that far, right?

It's yes. Let's avoid burning fossil fuels to make energy. And again, I'd rather that than nothing. Let's be honest, I'd rather energy access than no energy access at all.

You know, everyone was so obsessed with carbon. Where we're basically made out of carbon! And I think that there was a lack of education in terms of, you know, not all carbon is bad carbon. And I think the same applies for radioactivity, but we haven't gone there yet, which is, you know, some is good. I mean, you wouldn't be using it for cancer treatments if it weren't good. You wouldn't be using it to do X-rays. I mean, radioactivity is such an, you know, radiation is such an important aspect of our lives that I think is just underestimated.

I think a lot of cancer patients would go in with a bit more confidence if they truly knew, you know, the effects of, you know, radiation therapy, because it's definitely, you know, something scary. People lose their hair. You know, there are really, like, tangible effects that, you know, shock people.

I do think genuinely that there are some folks who are like, "I don't want to be irradiated at all." And so they go in reticently. You know what I'm saying? And so as a result, I think the mental plays also a very important role in diagnostics. But again, we're very off the nuclear waste discussion. But I think radiation as a whole and linear non-threshold are theories that actually hurt society more than help them.

Stephen: Just on that point, you mentioned linear no threshold, another acronym that scares the bejesus out of all those nuclear proponents is ALARA. Do you think the new recent executive orders and also other regulatory changes—are we actually gonna get rid of those things? If not, what's gonna take to get rid of them? And I guess the embedded in that question is, can you actually have a nuclear renaissance when LNT and ALARA are still in place?

Carl: Short answer is yes. The short answer is yes because... So I really put them on two different panes because one of them on the LNT is clearly an issue of what is a dangerous radioactive dose, right? And it's just assuming that any level of radiation exposure is bad. They basically took Fukushima and Hiroshima and then drew a line to zero. That's basically what happened. And I'm not, you know, I don't come from an engineering background, but I can tell you that that does not sound very scientific.

But coming back to ALARA, ALARA for context is “as low as reasonably achievable.” I think the NRC could do a tad better in terms of enforcing its own guidelines, its own requirements, and respecting its own processes that it's laid out. But when it comes to completely upending the regulator, I think that's a dangerous negotiation.

Because in fact, being anti-nuclear myself, I became all the more pro once I started seeing how the NRC works. Because how can you not? The nuclear industry has some of the most stringent requirements. I mean, this is safe when you see the level of scrutiny that they face. You realize really how safe it is.

So I think a strong regulator only enhances public confidence. But it also avoids us from doing some pretty reckless stuff in the private sector, which I think is important. I mean, there's a reason why the regulator exists. There's a reason we got to ALARA. There's a reason why we got to all the requirements that we have today. And I think that it's a bit short-sighted to just want to eliminate everything.

And this is a rather hot take actually in the advanced nuclear sector because no matter who you're speaking with, the number of times I feel like I'm being the lawyer for the NRC and defending them. But I just think that a lot of the folks talking about the regulatory process have actually not gone through it, or even initiated it because yeah, you'll have some conversations that are a bit frustrating, but think of it as a sports referee. I mean, if you're coming in, you know, aggressive and if you're collaborative, you'll get better outcomes.

And my experiences have only been positive with the NRC. And they've only been thinking outside the box whenever I have engaged with them. So I don't necessarily believe that they're always stuck in their own ways, but you know, it's interesting, many times I get in debates and I would actually ask if people worked with the NRC or had employees that were formerly at the NRC or if they themselves had a career at the NRC. And it's true, again, they could be more efficient with what they currently need to do.

But I think that by completely changing the rulemaking, by trying to eliminate a bunch of processes, we're not necessarily doing ourselves a service, because we don't want to learn the hard way why those elements were put in place in the first place.

Stephen: Yeah, every rule is there for a reason. Being pro-NRC is definitely a contrarian take. I guess a play on the Peter Thiel question: What important truths do you agree about nuclear—or do you believe about nuclear—that the rest of the industry disagrees with you on?

Carl: There are a couple. I generally believe that we should be building as many gigawatt-scale plants as possible.

Stephen: Say more to like play devil's advocate. Basically, hey, these plants have got super expensive. We can't build them on time anymore. The end state is it produces expensive electricity. Just shoot all those arguments down for us.

Carl: Yeah, I mean, if you look at today's Lazard numbers on what is the cheapest source of electricity, it's actually extended licenses for current plants. It's basically nuclear power plants whose life has been extended. They don't give you the price on day one. They give you the price today. And I think it's just a question of long-term planning versus near-term planning. If you're looking for that quick buck,

quick return, quick deployment for the least amount of capital outlaid, then you know, you could obviously go to much more capacity...you have less of that front-end risk.

But I think if you're generally trying to do a service to the people and pump electricity access throughout the world as much as possible, you've got to be building a gigawatt scale at a time. That's really my take. I mean, when you see plants like in Canada or in Japan where you have six to eight gigawatts on the same site, you're talking about very quality real estate that's powering over 10 million people. And that all fits on a couple of square miles. You're not talking about a very large patch of land.

So I think when it comes to material requirement per megawatt hour generated, there's just no better way than to pursue nuclear, period, full stop. And that's kind of what got me around the curve of being anti-nuclear. It's like at some point you're... This machine is producing more than any other renewable would produce. And I think it was a sea of consolation during a talk that said, with everything that happened to the AP1000, and literally everything that could have happened, happened to the AP1000...

Whether it's having an accounting scandal with the parent company of the prime contractor, whether it's COVID coming in during construction, the 08-09 crisis right before, I mean, you had strained capital markets, untrained supply chains, this was gonna be a first of a kind, everything that you could possibly imagine and more happened on that project, design wasn't finished, regulatory changes, I mean, everything. And they still delivered at a price that is cheaper than offshore wind.

So we have so much more margin to do better just on that construction. But it's true that it's been held as the worst construction project in history when I vehemently disagree. And I think that Georgians in 50 years will have the cheapest electricity and they'll be talking about how Vogtle 3 and 4 is generating the cheapest electricity in the United States. I wouldn't be surprised. Because all the repayment, you know, you pay back your loan on those 30 years or you do a refinancing, but ultimately those costs get amortized pretty quickly in the grand scheme of things.

Stephen: How do you feel about the legacy players, the Westinghouse of this world going up against the hot new upstarts, the ALOs, the Kairos, the Radiants? Do you see a place for the Westinghouse? Do you think they will be successful developing SMRs? Or do you think they're going to stick to the gigawatt scale plants?

Carl: They have a couple of products in their pipeline. Even amongst the smaller reactors, you got the eVinci, you got the AP300. So there's clearly no one-size-fits-all, right? And I was talking about gigawatt-scale reactors, but you have remote communities for which there's clearly demand, and they don't need a gigawatt-scale reactor. So I think everyone's gonna find their market. And I was just thinking about it from a more macro level.

When it comes to the upstarts versus the incumbents, the real question is will the upstarts have their spot? And you know, I think the incumbents have their spot already because whether you like it or not, they're making your fuel, they're replacing your pumps, they're providing your heat exchanger, they're just part and parcel with the whole process. And I think whether it's Holtec and Orano and NAC International and NAC on canisters for holding waste or if it's Westinghouse, GE, Framatome for the fuel, it's really hard to work without the incumbents.

And then when it comes to the new companies, the new entrants, I think it brings a lot of excitement and innovation, and I think they got to work together, if anything. I mean, look at Apple and IBM. They coexist.

Apple is definitely a bigger one. So what I think everyone is hoping is for these new companies to become even bigger. But if you look at the stock market and some of the market caps, you could arguably say that today. What I think is just that industry needs to deliver. We need to build what we say and say what we're going to build as well.

Stephen: When I think about what you're doing with Exodys, I think about the quote of "one man's trash is another man's treasure." Just maybe walk us through exactly what you're building, what problems it's solving. If I went into one of your factories today, what would I see?

Carl: So basically, we're developing, think of 15 to 20 container-sized modules that you would deliver to a site. You'd have like two stories underground, three stories above ground. You'd be building a concrete enclosure around it. And that's basically a recycling facility and it covers a hundred tons in a year. So it's scaled to market demand. And frankly, we had to bring folks from La Hague on our team.

When we were working on the reactor a while back, it was a team that was mostly composed of naval reactor designers, because we wanted that practical experience. We wanted to do the same thing here in the recycling business. And so our CTO worked for decades at Areva, specifically at La Hague. And I can't tell you how invaluable that La Hague experience has been in engineering our system, because it's true in the United States.

We've been doing a couple of recycling projects here and there. At H Canyon at Savannah River Site, we've been recycling research reactor fuel for a while. INL is currently downblending HEU from the EBR-II reactor to make available as HALEU for the advanced nuclear sector. So there's been actually some recycling in the United States and in fact, we're funded by the state of New York. We're very grateful for their support. But New York State also had a recycling facility, which is West Valley, which was a commercial recycling facility that was shut down very quickly in the whole midst of the Carter-Reagan conundrum.

We've done this before in the United States. It's just that the costs were not competitive with new uranium from Russia flooding the market once the Cold War ended. And not only that, it took the United States Enrichment Corporation, which is now called Centrus, bankrupt at the time in the early 2000s.

So I told you like we hopped different topics, but like when we do our clean recording, I'm actually thinking about some of the themes that I think are really important to nail down because there's so much on waste that is misconstrued. Whether it's like, is it legal to license it? And explaining why Jimmy Carter actually banned reprocessing. He didn't ban it because he thought it was generally, like, a problem and that we shouldn't do it. He banned it because everyone in the world were asking for one, two, three agreements with the United States and were stipulating the ability to reprocess.

And India in 1974, detonated a nuclear bomb with material that they reprocessed from a CANDU reactor. And so in 74, India detonates this weapon. And now every country is asking the United States, "well, we want to do enrichment and reprocessing." And so Jimmy Carter is like, "OK, there's no way we're going to get these countries to sign a one-two-three agreement with us. They're going to go and work with Russia. They'll go and work with the Soviet Union at the time. We need to get these countries on our side. Let's just say that we won't do reprocessing. So since we're not doing it, no one can do it and we call it a day."

So there's a lot of context that brought us to where we are today. And even in terms of the actual competencies in the United States when it comes to recycling is scarce, to say the least. And I really think

there's also an important job to do in making sure that we don't embellish recycling too much. Like, obviously, you can pull out radioisotopes from the spent nuclear fuel. There's some that you're going to pull out whether you like it or not.

Once you make that first chop the xenon and krypton are just bursting out depending on how old it is naturally. But when it comes to like other isotopes, you're looking for needles in haystacks, you know, and I think that recycling is a very good solution for uranium mining. Basically just pulling it out of the spent fuel.

But then when it comes to making like medical isotopes, I'd rather just take a cell and put it in a research reactor or in any type of reactor. It's much easier to do it that way. But I think sometimes when we engage with utilities, there's this tendency to feel like the recycling solution, it's either like a home run and a be-all solution for everything that you could possibly need in a lifetime, right?

So it's like, it's a treasure, but it's a quite tricky treasure to pull out.

Stephen: So France is kind of the leader, one of the leaders in nuclear processing, right? I believe they reprocess a good deal of nuclear waste every year. And how come they made that decision? Why were they so wise? Like many things, I guess. And then just talk me through the numbers of what France does today, just all the benefits that it gets from nuclear reprocessing.

Carl: So they have an annual capacity at La Hague which is roughly 1,700 metric tons per year.

Stephen: Put that into like numbers I can understand, like 1,700 metric tons like how many houses would that power? How many nuclear gigascale nuclear reactors.

Carl: I would say, yeah, so if you're taking it, in fact, actually that's a phenomenal question. I know that Orano has that available, but because what they do is, in the 1,700 tons of spent fuel that they process, what they do is they extract the 1% plutonium in every single, you know, used fuel bundle.

So they chop it up, dissolve it in nitric acid, a couple more process steps, you know, not to overcomplicate it, but basically they pull that... In spent fuel you have 1% plutonium, 0.1% minor actinides, roughly three, three to 4% fission products, depends on the burn up, whether it's, you know, a low burn up, medium burn up, high burn up fuel, how long it's cooled. And then you have basically 94-95% uranium.

So what's important to note is that in France, they take that 1% plutonium out. And usually they mix that plutonium with depleted uranium. And so you'll have like an 8 to 15 percent plutonium and the rest, you know, 85 percent to 92 percent being the depleted uranium. And that's a fuel called MOX, mixed oxide fuel. And in France, they use mixed oxide fuel. That's the way they do it.

Stephen: For all the reactors?

Carl: No, not for all the reactors, for a good portion of them. But even like, for example, Japan was looking at recycling, and it's true that not a lot of reactors are designed for MOX. So you do need to make design modifications when you use MOX. But as you can tell, you're separating pure plutonium. So as you could probably imagine, the birth of that process was initially to make weapons material.

As it grew in technical maturity, naturally it was going to be used for a commercial facility. As you may have picked up on, we're looking at 100 metric tons for a power processing system, which is basically using molten salts and electrowinning as the method to recover these valuable feedstock materials. But if we were to design a 2000, 3000 metric ton facility tomorrow, we probably would go with PUREX just because it's so much more ready on a TRL basis and frankly on a full industrial scale basis in terms of equipment sizing amongst other things.

But what's interesting with PUREX is it's also the process that the Russians use. Japan also has a PUREX facility at Rokkasho. It's Rokkasho-mura. It hasn't started up yet. That's a whole other conversation. But that's the process that was being done at H Canyon in the United States, at Hanford in the United States, and at West Valley. So that's a pretty well-understood process. But again, you're making MOX.

And I think what's important to note is today, France does not actually recycle its own MOX. It's not necessarily intended for the repository. There's a big debate. It's ultimately La Hague 2.0. The next version of La Hague will be able to recycle the MOX. It's being looked at as a good material for molten salt reactors. But ultimately what we did in 2018, 2019 is we chlorinated and basically tried to make molten salt reactor fuel out of used MOX. So that was already something that we did seven, eight years ago at this point.

But what's most interesting to me about what France has been doing is they've really been trying to repurpose all the materials that they get. Like they're even repurposing americium right now that they've been accumulating for space propulsion. So France has definitely been recycling since like the 1950s, 60s. And I think they also just realized they don't have any uranium mines. They always had to go work with a country like Niger. They lost access to those mines recently.

So recycling is a great way to minimize your need to import uranium. And I think the United States right now is at a point where we're literally using 1% of US-made uranium in our reactor fleet. So we're importing a lot. We're trying to drum up a lot of mines. But this is where I think recycling comes in and acts as a crutch.

Stephen: As someone who has spent over a decade in this industry, you're deep in the weeds, you're technical about it. How do you kind of evaluate where Oklo is right now? And why I ask you about Oklo is obviously it's talking about fueling the reactor in part with waste, right?

Carl: I'm not too familiar with their specific process in terms of recycling. Are you talking about progress in terms of deployment of a reactor, or are you talking specifically about recycling?

Stephen: Yeah, specifically about the recycling part, I guess, you know, it's hard to know exactly what's what when it comes to deploying the reactor. And there's so much more there than the actual technical feasibility. But yeah, just on the reprocessing side.

Carl: I think there's still some important issues that need to be solved that, from our conversations with National Labs seem to have not been solved across the board. And I think that's where the La Hague engineering really comes handy because there are even challenges that you will encounter on your 200th, 300th batch that the National Labs just frankly have never come across, you know, at their scale. So I have to say like it's been an honor working with them and you know, really excited to keep working with them.

But it's true that Exodys has not been very active in terms of marketing publicly its dates and its plans and who it's working with. And there's a reason for that is because we're more interested in talking about what we've done versus what we're going to do. And I think when you're a public company, you need to constantly be on those earnings calls. You need to be putting out headlines every other week. And so I'm not sure, you know, what the difference is between, you know, headline versus, you know, material progress.

And that applies for everyone. I want everyone to be successful in this space, frankly. I mean, there's so much that needs to be done if we are to really create the world that the Rational Optimists portray. And their success being one of those things that I think will help us get to a nuclear future quicker.

Stephen: Obviously, there's the AI demand stuff that's really reawakened people to nuclear energy and why we need it. There's the regulatory changes. In your opinion, what's the most important change or shift that's happened in nuclear over the past two or three years?

Carl: I feel like the watershed moment was the deals that Meta, Google, Amazon were all pursuing with different advanced reactor vendors. I think that's what really like, re-initiated or at least cemented the fact that there was this reopening to nuclear. I think the first watershed moment was probably the Advanced Reactor Demonstration Projects, the ARDP program, because that really showed that the U.S. was serious about advanced reactors.

Rewind to 2015, 2016, 2017, it was like, the priority is safeguarding our current reactors. It's not pushing advanced reactors. Like we need to keep the current fleet going. We need to make sure we avoid shutdowns. So the industry was more in damage control than it was really in going out there. And so even though we talk about the hype today, it's super refreshing to see that now everyone's on like the bullish case around nuclear. And we're talking about advanced reactors we're talking about everything that nuclear technology can do and that is tremendously refreshing and encouraging because where we were ten years ago, when I started in the space was we're closing plants down.

My first exposure, really, to nuclear you know in person is attending a talk where I'm seeing the representative of a utility just pleading, saying, "can you guys imagine what we're doing for our air by shutting down this nuclear power plant that we own in Massachusetts? As a citizen, as a citizen, we're gonna replace that with gas." And just seeing how passionate he was and how much he cared, like that was an important moment for me.

And so, just coming back to like, what is the one thing that's most important? I think the demand. I think solid demand. And I would even go a step further. I think the most important thing to have happened in the last 10 years is what Amazon just did with X Energy. Because they put \$700 million into the company to build the TRISO-X facility as well, to use those proceeds for licensing for supporting the first order book. And then they put 300 million on the start of the construction for licensing and for procurement of key pieces. Like they're building.

Natrium, TerraPower, they carried the industry, the advanced nuclear sector forward. They were developing the new Part 53, then decided that they're going to focus maybe on their first deployment on a Part 50, or like a hybrid of a Part 50 and 52. And they're putting out equity to fund this plant. Like they're using their own money to pay for the construction.

I think there are a couple of companies like that that really were the first ones who then enable a world for all the other ones to kind of follow and jump on that demand. You can now be a person with a PowerPoint slide and raise a handful of million on some new microreactor concept just because there's been those demand indicators.

I think that's the most important thing is the clients have finally showed up.

Stephen: I won't ask you who is going to be the first company to turn on an SMR in America, but I will ask you for your opinion on which avenue will it come from. You mentioned the Part 52, the Part 50, you obviously have the DoD and the DOE lanes and then just generally NRC lane. Which do you think has kind of the best shot? And when in your best estimation? You know, obviously you have that July 4, 2026 date.

Carl: Yeah, and that one, and you know, honestly, if...I understand the importance of hitting the deadline, of doing things on time, on budget and everything, but I would really encourage all the advanced reactors that are thinking about deploying by then. And again, I don't think a lot of them are actually intending to fully deploy by then. It's just a great date, but even in their applications, they're not saying that they would go critical on July 4th.

But I think this is a great opportunity to get your test reactor going, you know, through a DOE authorization and get very valuable data and be able to operate this, you know, for a handful of years and not intend to have it be the commercial one. But if it's to go critical and then shut it off, I think that's the stupidest idea out there because you're gonna end up with a \$100 million waste cleanup. I mean, I'm telling you, Shoreham in New York operated for nine days—stranded nuclear site. Nine days of operation will do it. It'll make that site unusable for decades.

So I think it's going to be important for those companies to really use this as a great exercise for a longer-term objective than just going critical in the near term and saying, we did it. Now then there's the, it's difficult in terms of avenues because if you're thinking about like X-energy, for example, like they're, they're really good candidate. But you also have TerraPower that's in construction, but still waiting to get, you know, their full access to fuel.

Hot take, a hot take. I would say that my dark horse in this SMR race is actually Holtec.

Stephen: Canada, right? The Darlington site?

Carl: Holtec? No, no, no, so that's the BWRX-300. That's GE. But interestingly enough, Holtec is a very impressive company.

Stephen: They make the casks and stuff today, and then decommission the plants, right?

Carl: Exactly, they decommission. They, you know, they know how to tear components apart. They know how to do, they, you know, they designed a reactor I think with probably the best maintenance schedule and procedures out there because they know how to cut these, you know, and they've been dealing with it with Holtec decommissioning.

They've also like quasi self-funded their entire reactor program. So they're not putting out headlines every other day saying, "we did this and we did that" because they don't really need to pitch to investors. So I think they're gonna be a very interesting one because Holtec also owns nuclear power plant sites,

right? Which is something that not a lot of other folks have. I mean, they're restarting Palisades as we speak.

So I think there's also a real estate issue here, a siting issue there. They're not going to be stuck in as many hearings, I would say, as other folks building on Greenfields. So it's complicated because I think that the most viable avenue is probably SMR working with utility which is why you know X-energy, TerraPower I think are solid candidates working with utility—not a data center, a utility.

And the data center could be the client but as long as there is a utility in the frame, I think that's going to be deployed first just because utilities are very different organizations from advanced reactors like it's mostly legal organizations it's...you know, they're maintenance organizations, they're employee—they're operator training organizations, they're legal organizations that have to interact with public service commissions, the regulators, FERC, amongst others.

So it's just not the same reflex. It's not the same muscles that you're flexing when you're a utility versus an advanced reactor vendor. So I think the projects that have decoupled the vendor from the utility, from the client, or at least from another data center client, are the ones that are gonna be the most successful in the near term.

When it comes to part 50 or 52, I think part 50. The reason for that is because I think part 50 gives you the flexibility to actually modify the design on the fly. Because when you go through that first process and that construction permit application, you actually get some feedback from the NRC saying well you should probably change this so you want to incorporate that feedback and then when you start the operating license application or at least you know submit it then you're going to be reviewed on that.

So you want to have a bit of that design flexibility. I mean what you saw with NuScale is they licensed their 50-megawatt electric design under part 52, got their design certification, then wanted to push it up to 77-megawatt electric without making any major modifications, and they had to recertify that. So I think a part 52 will be great as we go forward into the future. But I think part 50 in the near term is probably the best, especially as we try to refine these designs.