



Episode 6

Nuclear Mailbag

Packy

Julia, episode six. Hope you had a great Thanksgiving yesterday. Because it was Thanksgiving, we're doing something a little different. Now that we've done five episodes on nuclear fission, we're going to do a catch-up on what's happened in the nuclear industry. Luckily, things are moving fast.

Then we'll do a mailbag. We've gotten a bunch of questions and feedback. YouTube comments are a new experience for me, so we have a lot of those to address.

Julia

Let's dive in. I was excited to get a bunch of questions and comments along the way. I thought we could start out, Packy, with a summary of what's been going on the last few weeks. What's exciting about nuclear right now is there's been a lot of current events.

Let's start with the first one. What's going on in Illinois? We talked about Governor Pritzker and what's happening related to their legislation around nuclear and the moratorium. What's the latest, Packy?

Packy

I think it was episode one where we started with this idea that Governor Pritzker vetoed the last bill that the Illinois House and Senate tried to pass to allow new nuclear and lift the state's moratorium. He got booed and dunked on all over Twitter. Then the House came back with new legislation that addressed some of Pritzker's concerns. Namely, they limited the size of the nuclear reactors in the state to 300 MW, that small modular reactor range we talked about in episode four.

Lo and behold, it passed 98 to 8 in the House and 44 to 7 in the Illinois state Senate. So overwhelming bipartisan support, and now the bill goes back to Pritzker. We'll see if he vetoes it. But it seems like democracy working, right? Reworking the legislation, the people having the vote, and saying we want at least the option to build new nuclear in Illinois.

Julia

It's been such an emotional roller coaster to watch this. Everyone cheering for nuclear is like, "Come on." Such a message the legislature is sending. If Pritzker vetoes this again, it's going to be ridiculous. It's been exciting to see everything moving in a pro-nuclear direction. I'm hopeful this will pass, and it makes me hopeful for California eventually revisiting this topic.

There was briefly a bill introduced last year that didn't even make it out of committee in California. Everyone was citing nuclear waste as the issue. If Illinois can set a precedent of passing this in a state with strong anti-nuclear Democrats, I'm hopeful we could see things change in California. There are about nine other states that still have a moratorium, but they're slowly starting to fall, and it's great to see.

Packy

We love to see it. It's not a law saying you must install nuclear. All we're asking for is for nuclear to get a shot, to not be illegal, and to compete on economics.

To that end, though, we have some bad news coming out of the western states and NuScale. What's going on there?

Julia

Yeah, we've had the first setback in commercial SMRs. NuScale, which we've referenced before on the show, was the first SMR design approved by the NRC. They were set up to do an installation in Idaho with UAMPS, a consortium of about 50 power groups across seven states. Unfortunately, costs had been creeping up, and the subscription demand needed to complete the project wasn't going to make it.

They wanted 80% of these utilities to sign up and buy power, but people were getting cold feet. They ended up canceling it because they weren't going to reach that subscription level. Natural gas is so easy to access in the western states, and so super low prices create competitive price differences. It's unfortunate that this first-of-a-kind SMR project, which many were excited about, isn't going to come to fruition.

Packy

Setback there. But if you told me at the beginning of the season that this was happening, I would have been more concerned than I am after doing some of our episodes. When we talked to founders building advanced nuclear, many discussed the importance of choosing your first market and said these communities wouldn't be the first to sign up for new nuclear.

The approach at Antares is working with the DoD, while other companies are going to places where nuclear can't compete on cost initially, but it's the best or only solution for that particular use case until you can come down the learning curve. It's a bummer to see this one fall through because of rising interest rates and higher construction costs. But it speaks to the importance of choosing the right customer first and then making a lot of these things come down the learning curve.

Julia

I even saw commentary that in places where you have LNG, not just piped natural gas, this could be more cost-competitive. If you go to a place where they don't have their own carbon resources to pull from right down the road, you might be in a much better place to make a fission project.

Packy

And then there's the third one. We're going to end on a positive note. This one is less specific. There's real legislation being enacted in Illinois, there's real economic considerations at play in municipalities choosing to buy in or not with UAMs.

A Bloomberg story last week reported that the US is leading a group of countries, including the UK, Sweden, France, Finland, and South Korea, in a push to triple global nuclear power capacity by 2050. They're going to introduce this at the upcoming COP 28 climate summit. We're light on details, but they're talking about nuclear companies dedicating themselves to meeting the demand for that tripled capacity, and working with the World Bank and other international financial institutions to treat nuclear the same way as wind and solar and other renewable energies.

This could unlock clean financing for nuclear, which is huge. It's one of the crazy things - nuclear hasn't been considered clean, limiting its access to financing, even though it's one of the cleanest energy sources alongside solar and wind. It's great to see that recognition if they follow through, and it's great to see the US leading the charge there.

Julia

Yeah, this is a huge shift. Previous COPs have never had nuclear. There were too many anti-nuclear people, so it wasn't even allowed to be brought up as a topic.

It's really exciting to see.

Packy

People always said these global international climate summits aren't taking climate seriously. Maybe they don't actually believe what they're saying if they're not including nuclear. Now they're including nuclear. So maybe we have something really to worry about on that side.

But I think it's awesome recognition and gives nuclear another shot to compete on a level playing field.

Julia

Yeah, totally. Well, let's dive into the questions. We've gotten a bunch of questions and comments along the way.

Packy

We'll answer some of these ourselves. We've also asked some of our friends to come in where they have real expertise. So you'll be hearing us talk about it, and you'll be hearing clips from other people throughout the episode.

The first one is a DM from Josh Payne, who runs a nuclear startup himself: "Great first two episodes of the new podcast. One thing that I didn't hear discussed in the history section was the QA or quality assurance program and standard changes in 1969 and 1970. 1970 was when the AEC adopted a nuclear-specific QA standard and specifications. Prior to 1970, the standard and programs were the same as all other boilers, pressure vessels and heavy industries. The QA requirements are one of the main reasons making new builds in the US so difficult."

So what's going on here?

Julia

For this one, we turned to Jim Hopf, who I've met via some nuclear advocacy work I did around Diablo Canyon. He's a retired nuclear engineer and has written about this topic.

So I'll turn it to Jim.

Jim Hopf

The 1970 AEC decision significantly increased costs for nuclear in the future. It's probably one of the most important decisions in terms of the cost arc of nuclear going forward. Reports show that nuclear-grade versions of components cost 3 to 50 times more than non-nuclear versions. There's a saying in the nuclear industry that the main factor determining the cost of a nuclear project is not the amount of steel or concrete, it's the amount of paper - mainly referring to QA documentation. My experience in the dry cask storage industry corroborates that. Nuclear grade requirements added a lot to our effort, time, and cost.

When the dry cask storage industry was in its infancy, we used typical industrial suppliers for steel and concrete components. After the NRC clamped down, those suppliers either greatly increased costs or gave up entirely. The higher costs for nuclear-grade components are not just due to stricter QA program requirements, but also because the nuclear QA program is unique and different from standard industrial QA programs. This results in a much smaller supply chain with inherently higher costs.

Now, another alternative might be to try to go to these large suppliers and ask them for their equivalent component. But we'd need them to suddenly use an entirely different QA program. An IAEA report, which

studied supply chain issues for SMRs and maybe nuclear in general, made a key point: if you ask a large-scale non-nuclear supplier to suddenly switch to a totally different QA program for one relatively low-volume supplier, it not only leads to much higher costs for nuclear-grade components, but it might even reduce quality.

They had it down to a science for their non-nuclear equivalent products with the standard industrial QA program. Now you're asking them to suddenly shift gears. It's very disruptive. That same report concluded that if SMRs, or maybe nuclear in general, are to be deployed at scale at an affordable cost in the future, they'll have to use a lot more industry-grade, as opposed to nuclear-grade qualified components. This is a very important issue.

The industries these non-nuclear suppliers were providing for weren't non-safety industries. Many of these industries actually require very high degrees of safety, whether it's bridges, buildings, or airplanes. Nuclear isn't the only industry that needs a high level of safety. And those suppliers have been achieving a high degree of safety with their own QA programs. Frankly, if a bridge falls down, a tall building tips over, or a plane crashes, that'll actually cause more deaths than a nuclear accident would.

So one of my big points is, why is this necessary? I'm a big believer that if we switched over to more reasonable QA requirements, or perhaps even existing QA requirements, it would cause a very significant drop in the cost of reactors going forward, perhaps especially for SMRs, as this IAEA report suggested.

Packy

The point on QA from Josh and Jim's answer shows how deep this whole topic goes, to an insane level of detail. One of the first pieces of feedback we got was that we missed another piece of detail. It shows how complex this topic is and how many pieces need to be unwound and worked on to make nuclear competitive.

Thanks for listening so far. We'll be right back after a quick word from our sponsors.

This next question comes from YouTube commenter @ribbonwing, who said, "I'd love to see a follow-up comparing and contrasting this with other countries. France had a fairly successful nuclear program, but doesn't seem all that impressed by it. Both the Soviets and the Chinese have nuclear power, but they don't seem to have had much more luck with it than we did. Why haven't they been more successful than we were?" I'm going to give this one to you because it's a toughie.

Julia

This is a great question, and I'm happy they called out France. France decided to make a big commitment to nuclear in the seventies. Now almost 75% of their grid runs on nuclear energy, which has been huge for them, both on generation costs and meeting carbon goals. Unlike Germany, which has been progressively shutting off their nuclear since 2011 after Fukushima, committing to eliminating nuclear entirely (which they achieved earlier this year by shutting down the last few nuclear plants and turning on coal), France remains a country with a much more stable and cleaner grid.

The Soviet Union, now Russia, and China are building more nuclear right now than anyone else in the world, certainly more than the US. China is interesting because they're relatively new to nuclear. Only a single-digit percentage of their grid is nuclear right now, but they've made a big commitment to lowering carbon emissions, evident in their commitment to building out solar as well as nuclear. They're experimenting with different designs, including the AP 1000 and molten salt reactors. I give them credit for really going for it. Time will tell if they're able to get all these reactors online, but it seems promising.

We'll likely see them expand this into Belt and Road initiatives, offering nuclear power programs to other countries in the form of loans. The US should get involved here and become a leader in exporting nuclear technology again. Russia has about the same percentage of their grid from nuclear as the US does, just under 20%. They have abundant natural resources, which may be why they haven't increased their nuclear percentage. But they're also exporting, so they take it seriously.

Lastly, Ukraine, formerly part of the Soviet Union, has about 55% of its grid from nuclear energy, almost as high as France. I give kudos to them, especially considering Chernobyl, for being committed to nuclear energy and having it work well for their energy security.

Packy

There's a lot to unpack there. First, the premise that France hasn't had spectacular results. When you compare it with Germany, they haven't had to shut down industry in France to the extent that there is industry and people work more than 35 hours a week. I think France is a success story. It was threatened recently, but Macron pushed back and they ended up keeping their nuclear capacity online. So big win for France there.

China is going to be this amazing kind of miracle project, if it works. They're going to triple or maybe even quadruple their grid capacity over the next decade. Isaiah on a previous episode mentioned that China is using old designs and repeating them, manufacturing at scale. They can take the land and put it wherever. It'll be interesting to see if they can get things done quickly and cheaply. They're estimating \$2 to \$3 billion per gigawatt, which is a lot cheaper than we do it here.

You're right, one of the reasons for the COP 28 announcement or rumor coming out of the US is probably because the US wants to start exporting these things as well. Just like we want our AI to spread across the world instead of China's AI, we probably want to be the ones providing power to the rest of the world. If China's doing it, it's actually good for the world - this kind of competition between the US and China. I like these proxy wars where it's on nuclear energy and getting more energy to more countries. Hopefully, we keep spurring each other to do more on that front.

Julia

I love that point, Packy. And we've talked about the nuclear energy cold war. Let's bring it back and start competing to do good things on long time horizons like building nuclear power.

Let's make that happen.

Packy

Amen.

Julia

This next comment is about solar. We covered this briefly, talking about LCOE or the cost of putting new solar on the grid. The comment is about whether we missed some things. We included some things, didn't mention others.

We'll pause here to dive a little deeper into the solar cost curves with Robert Bryce, an author who wrote "Power Hungry," a book that talks about the myths of green energy. He is a skeptic of renewables. We'll dive much more into the topic of solar in our next episode, where we cover all the different energy sources beyond just nuclear. So we're getting the full energy landscape. A lot more to come. We'll hear from some very pro-solar people as well on the next episode.

Robert Bryce

Hi, everyone. I'm Robert Bryce. I live in Austin, Texas, and I'm an author, film producer, and podcaster. I spend a lot of time thinking and talking about energy and power systems, particularly looking at which systems are being promoted and getting a lot of press. There's no doubt that solar energy gets a lot of attention. Many claim solar is getting cheaper and is the cheapest form of generation, so we should go completely solar. There are advantages with solar. It runs on the sun. I get it. And the cost of solar has gone down. But there are serious problems, including the intermittency issue, Chinese supply chains, including forced Uyghur labor in some of these supply chains.

The fundamental problem, as I've reported repeatedly, is land use conflicts raging across the country. I just updated the Renewable Rejection Database. In 2020, there were just two solar rejections. So far this year, there have been 65 solar rejections, and in 2022, there were 88. It's happening all across the country. In just the last month or so, there have been rejections in Kansas, bans on wind and solar in Harvey County, Kansas, and Venango Township, Pennsylvania. Their planning commission rejected an 80-megawatt solar project that was

going to cover about 900 acres with solar panels. This doesn't fit the narrative from big NGOs promoting renewables. But this is the reality.

No one has ever questioned the numbers in the Renewable Rejection Database. The numbers are the numbers, and they're not my numbers. You can check them out yourself. So at your convenience, check out the Renewable Rejection Database. I'm proud of that work, and I think it's important to understand the limits, values, and attributes of various forms of energy generation. But we also have to take a very sober look at the downsides. Land use is the downside for both wind and solar. You can find me on Substack at robertbryce.substack.com. Thanks a lot.

Julia

This next one is from @smokecakes on X: "What sectors are the biggest winners from getting nuclear to a transformative price? What would the effect on society look like?"

I can think of desalination becoming relevant for large-scale agriculture, data and AI centers becoming energy unconstrained."}

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Packy

This is one of my favorite questions. It's actually one we're going to dedicate an entire episode to, the last episode of the season. The point isn't just to have more nuclear energy or more energy. The point is to be able to do the things that having cheap, clean, abundant energy allows you to do. Certainly, desalination is one of them. Data centers for AI are incredibly power-hungry and are going to demand a lot more energy. There's a bunch of really cool things we're going to be able to do if we have more energy.

If you look at the history of human progress and GDP growth, it tracks really well to how much energy either humanity at a given time or certain countries are able to consume. The world gets better with more energy. But we're going to save the specifics for episode ten.

Julia

This next one is from @manila_zilla on X: "Would love to hear your views on investing in nuclear (physical sprout ETF, miners) and viability of uranium itself if fusion takes off."

We'll hear from Tim Rotolo of Range fund holdings for this one.

Packy

This was a timely question because we're introducing a new sponsor to the podcast: Range Fund Holdings. They have a nuclear ETF launching in December, and we're excited to bring them on as a sponsor. Timothy Rotolo from Range Fund Holdings provided an answer. He wants us to note that this is not investment advice. Full disclosure: Their investment advisors manage a uranium-focused strategy, and entities he controls manage uranium mining index products. They may own securities discussed here.

With that caveat, he's an expert who's thought more about nuclear ETFs than maybe anybody in the world. Here's his personal opinion: Tim told us, "My personal opinion is that fusion is far from broad commercialization and even further from broad deployment. Uranium is a cyclical commodity, so the current investment opportunity will likely be in the rearview mirror if and when fusion is a practical reality competing with uranium demand. The investment opportunity set for nuclear to date has been narrowly focused on uranium and uranium mining. In my opinion, there are two separate and distinct opportunities today. First, the supply deficit-driven situation in uranium remains quite attractive, but it's a historically cyclical commodity. Second, the demand-driven nuclear renaissance offers secular opportunities across niche fuel providers, advanced reactor technology companies, service companies, utilities and more."

The supply deficit-driven uranium opportunity has a simple thesis: the price of uranium needs to rise to incentivize new production to fill the supply deficit. This has several ways to gain exposure, depending on your capital size, risk, and illiquidity tolerance. For simplicity, he'll discuss the public opportunities, though private direct and fund investments are available. One caveat: global uranium is a highly volatile commodity with a very real left-tail risk in the form of a nuclear meltdown. This is a very small risk but it's real and would likely cause a large sell-off.

Here are some investment options: 1) Physical uranium proxies via exchange-listed funds like Sprott Physical Uranium Trust or Yellow Cake in London. Pros: Reasonably liquid, track spot uranium price. Cons: Can trade at large discounts with no direct mechanism to close, can experience equity volatility. 2) Sprott Uranium Miners or UURNM (non-US investors). Pros: Pure play with exposure to equities and physical uranium. Cons: Volatile and less liquid for large investors. 3) Global X URA. Pros: Very liquid. Cons: Only 75% pure play uranium, 25% nuclear services. 4) Sprott Junior Uranium Miners. Pros: Liquid way to play junior exploration and near-term producers. Cons: Very volatile, companies may require more capital and dilute equity owners. 5) Single-name stocks. Pros: Potentially more upside if you identify something you like in the ETF. Cons: Highly idiosyncratic, mining issues, management issues, risk of dilution.

There's also an emerging opportunity in the demand-driven nuclear renaissance, which is more of a picks-and-shovels play (service providers, companies constructing reactors, etc.). Today the primary option is to own individual securities, but they've created an index. The symbol on Bloomberg is NUKZX, and it attempts to capture the entire supply chain from fuel to advanced reactors, service providers, and utilities, with minimal mining exposure.

Again, this is not investment advice, but an interesting way to think about investing in nuclear in the public markets if you're interested.

Julia

This next one, also an X comment from @damccormick13, Packy's brother: "If we get energy right in the next ten years, do any of the things we currently consider eco-friendly in our individual lives actually matter? That is, recycling, paper straws, not using plastic bottles, etc."

Packy, what do you make of this one?

Packy

Paper straws can get lost. If we never use a paper straw again, I'll be happy. To me, pollution and waste are different from energy usage and carbon being released into the atmosphere. We don't want a planet full of litter or fish and dolphins choking on soda can holders.

But I think the broader point of the question is that we major in the minors, so to speak, on a lot of things. We focus on these little paper straws while opposing nuclear. We have these big, chunky energy solutions on the sources side, and then we spend all our time thinking about the uses side. Turning off a light bulb saves a tiny bit of energy. That's great if you want to prioritize that in your life.

But I think the most important thing you can do is just put more clean energy on the grid cheaply. I think conservation is a bit of a dead end generally, and is maybe something that people feel they can control in their lives, but doesn't make that big an impact compared to just putting more nuclear or solar or whatever your preferred clean energy is online.

Julia

Yeah, I think that's exactly right. There's a lot of penny-wise, pound-foolish environmental activism going on. No problem if you want to use a paper straw, great. But I think the most important thing here is that we're cultivating an environment where we're constantly innovating, oriented around progress.

We're deregulating where we can, so we're not all tied up in red tape. If we can have an environment like that, we're just going to be moving so quickly towards things that are ultimately much more environmentally friendly and also positive for humanity.

Packy

Flourishing is such a good way to put it. There are a couple of great examples I love here. One is direct air capture, which we talked about with Valor Atomics and will discuss with Casey at Terraform Industries in the next episode. This huge problem of too much carbon being released into the atmosphere might actually have a technological solution: if you have cheap and abundant enough energy, you just pull it right out of the air and either put it in rocks or do something productive with it.

There's also this great book, "The Case for Nukes" by Robert Zubrin. He also wrote "The Case for Space" and "The Case for Mars", which helped inspire Elon at SpaceX and Delian at Varda and others to start those space companies. It's an aggressive pro-nuclear fission and fusion book. One of his points is that once we get fusion advanced enough, we could shoot plasma at landfills and break down all the materials we've used back into their component elements to reuse.

His big contention is that there are no natural resources other than human intelligence. Everything in the ground is useless until we figure out how to use it. And we can figure out how to reuse it once we achieve energy abundance with fusion. So if you want to recycle, do that. If you want to use paper straws, knock yourself out. But hopefully, the goal we're going for is a world where you don't have to worry about paper straws.

Julia

Speaking of human intelligence and ingenuity, we have a comment from @mccrann on X: "Let's get @PalmerLuckey on... the latest episode segment on Pirate Wires was on nuclear weapons and how the US went too far in turning nuclear off."

My response to that is, come join us anytime, Palmer.

Packy

Amen.

Next one on X is @jackcalvinross: "Interested to hear y'all's thoughts on nuclear waste recycling and reuse. Seems huge, but can't tell if it's just a new shiny thing in the space." What do you think, Julia?

Julia

This is an interesting one. I think this is one of those distraction problems. It would be nice to see more recycling and innovation around nuclear reactors that can run on waste. But we're missing the point here. We need to start building more nuclear power so we can get more clean energy online.

As we discussed in earlier episodes, nuclear waste itself leaves a tiny footprint and hasn't harmed anyone since it's been around. The nuclear waste we've used in the US over the past several decades can all fit on a football field and it's stored on-site in concrete casks. We have a great system to do it.

To me, it's not a problem to prioritize solving right now when we're not even able to get new nuclear power plants online. So I would say it's a bit of a shiny object distraction.

Packy

That's a great answer. I love that we're keeping it real here. I guess my one question would be, does it help maybe with approval if you can say, "I have this new plant, and it eats all the waste that you're worried about and uses it as fuel"?

Do you think maybe the NRC or just Congress looks on that more favorably?

Julia

But I don't think it actually matters. The NRC will say this is a new design. We're talking about long timelines to even get something like that passed. The NRC hasn't regulated anything like that before. Not to say it isn't

worth going for, but there's a huge hurdle there. And then the second thing is, again, that's not the issue stopping people from being able to get licensed or build something new. We have the waste issue relatively solved. The one area where you're still seeing this be an issue is in California, for example. When they tried to pass the bill to overturn the moratorium on nuclear in California, the number one reason cited by those who said no was that we don't have a solution to nuclear waste. So there are some people still holding themselves back on this topic. But in the macro sense, I think it's a small issue. I think we have a lot of other ways we need to push the industry forward and shouldn't get bogged down in waste questions.

Packy

I love it. Trey Lauderdale, who's out there fighting the good fight in trying to extend and even expand Diablo Canyon, asked us a question on X. He'd love to see an episode on who the leading investors are in the space and how developed the ecosystem of angels, early/late stage VC, PE and strategics is.

Julia, you just got off a fundraising process for a nuclear company. So give us a little overview of the landscape.

Julia

Yeah, I love this question. Nuclear is having a resurgence right now. Over the last decade or so, many companies have started up, but this is not a massive category. You almost wouldn't want to see hundreds upon hundreds of companies, because then we might be spreading ourselves too thin in terms of talent and other things. I'd say it's kind of a niche within the hard tech category.

There are some people going directly at nuclear as a category. Rod, who we've had on the show, has Nucleation Capital, which is entirely focused on the nuclear industry. You get some great benefits when you're really deep on a topic - you're very well informed when analyzing companies and making investment decisions. So that's a niche to be in.

But most investors have nuclear as one part of a larger portfolio. Sometimes it's a portfolio that's exclusively hard tech focused like a16z's American Dynamism portfolio. They have nuclear as part of a broader category there. And then there are others who are generalist investors just starting to get more interested in the hard tech category and including nuclear in there. So I think we see a range, but broadly, nuclear is going to be one of many across a portfolio.

Packy

I love that. I think Rod, and then we had Katherine, obviously, talk about the way that she sees the world of energy, where Katherine thinks that it's a category that supports one absolutely massive winner, whereas Rod explicitly told us that he thinks it's a category where there's going to be a lot of different types of reactors and sizes serving different end markets. So that's two different philosophical approaches.

I think fund size also matters. For American Dynamism at a16z, they're probably trying to look for these really, really big companies that can own the market. And for someone like Rod at Nucleation Capital, focused on nuclear with a smaller fund, you can get these pretty good outcomes across a bunch of different categories. But the space is so early, it seems like there's a lot to be worked out.

Julia

Yeah, absolutely. Okay, this next question is from @michelecanzi on X: "What's the policy playbook in the West to shift investments from renewables to nuclear?"

Let's turn it over to Brett Rampal. He used to do nuclear policy over at Clean Air Task Force.

Brett Rampal

I'm Brett Rampal, the director of nuclear and power strategies at Veriten and chief technical analyst at Segra Capital Management. Today's best policy levers to entice investment in nuclear energy are largely the same things the industry and advocates have been asking for decades: equal consideration with other clean energy

technologies on a more even playing field.

The recent passage of technology-inclusive clean energy tax credits in the Inflation Reduction Act (IRA) really changed the calculus for many investors considering the nuclear space. We've seen announcements and commitments from companies directly in response to these new incentives. These tax credits put future nuclear energy technology projects in the same category as other clean energy technologies, and on top of the IRA tax credits for existing nuclear power plants, this really changes the entire landscape of thinking around nuclear energy.

However, beyond continuing to seek and improve that more even playing field, numerous other policy areas remain that could be addressed to support increased investment in Western nuclear projects, such as: 1) Supporting domestic and global uranium enrichment and conversion capacity to limit Russian involvement in Western fuel cycle activities. 2) Supporting the development of nuclear fuel manufacturing and additional nuclear supply chain manufacturing activities. 3) Taking meaningful action on spent nuclear fuel management. 4) Supporting domestic nuclear research reactor capabilities for testing and qualifying future nuclear technologies. 5) Implementing cooperative policy across the Department of Defense, Department of Energy, NASA, and other government entities currently engaging in nuclear energy demonstrations to share lessons learned and potential resources. 6) Developing cooperative policy across international borders to limit serial regulatory burdens and the regulatory burdens of newcomer nations. 7) Providing oversight and additional support for already under-development domestic regulatory frameworks for future nuclear technologies. These are just several examples of strong policy levers that could entice more investment for nuclear energy.

Packy

All right, @MsMurph_ on X is giving us a layup to start: "You're at a dinner party with interesting and interested people. No one is deeply knowledgeable about nuclear per se.

Someone comments: 'nuclear is bad because nuclear waste is bad.' What is your single sentence reply?

Julia

Nuclear waste has a tiny footprint, the size of a football field for all the waste we've ever generated in the US in the past few decades. We have a playbook to manage it on site at power plants, and it's never caused anyone any harm.

Packy

That was a great answer. I'm going to cheat and say my one sentence is, "Hey, check out this chart." The chart is from Hannah Ritchie, who works with Our World in Data, and it's hypothetical cumulative waste generation per person over 25 years in the UK. It's striking because on the left side you have municipal waste at 12,125 kg. In the middle, solar photovoltaic cells at 201 kg. Then all the way over to the right, nuclear at 3.69 kg. It's this tiny amount.

We'll tell you in a million different ways, the football field thing, the fact that they can store it, but it's this really tiny amount of waste. And I trust humanity to be able to deal with amounts of waste that small in a safe way.

Julia

Okay, next one here from @cornoiseur on X: "Will it take a crisis to create the necessary conditions for more political support of the AP 1000? Think Winter Storm Elliott, but if more gas lines froze up and we had a big blackout."

I think what's interesting here is this points out gas lines. Natural gas is not as resilient as we might think, and it's also incredibly volatile in pricing. We've seen a lot more natural gas come online in the US in the last decade or two that has been the leading driver in reducing our carbon emissions. You change out coal for natural gas, which has less than half the level of carbon emissions. But that's not something we want to wholly replace our grid with. We know that when we build out renewables today, we build out peaker plants with natural gas to run when the renewables are not generating and there's still demand on the grid. But we don't want to go to a

majority natural gas grid, which actually 50% of California is, and then have issues with that.

So, yes, I think a big blackout like this would cause more awareness, but it's all about the narrative that's being told. Whatever narrative the media grabs onto in terms of what caused the storm and what we should do about it is going to be the most important part.

The fact that more people are aware of nuclear energy now, and there are a lot of advocates working tirelessly to help get the message out, is going to be important in terms of letting people understand why nuclear is a great, resilient form of energy, and why people should be demanding it from their politicians and local utilities. Building out nuclear is not going to be fast, it's not going to be a quick fix to blackout issues, and it's going to be something that people need to agree needs to be done for the long term.

Packy

When you put it that way, it does seem very hard. The two things people are not good at are patience and giving up something now for something in the future. And then there's the media narrative piece. It's a great point and is really hard even if you have facts on your side.

We're recording this a couple of days after SpaceX's second Starship launch attempt, which was a success by every goal they set out. They went farther than expected. The separation of the two stages happened beautifully. There are incredible images that anybody with a heart and soul should be inspired by. Yet when you look at the press - tech press, traditional press - it's "SpaceX rocket blows up again." How is that the story you take away? Getting that narrative right when the media has an impression of something in their mind, or when it's hard to understand, is challenging.

Yes, maybe if you haven't thought about it before, a rocket blowing up at any point in the mission doesn't sound very good. Maybe there's some more communication that can be done there. Maybe papers sell more when they talk about rocket blow-ups as opposed to successes. But I do think that's a really, really hard thing to change. We're doing our darndest over here to help change it, but we need everybody listening to go spread the word.

All right, this next question, also from X, comes from @jabridge. He's asking for a "deeper dive into developing nuclear projects, including a discussion of grid interconnection challenges and the regulatory approval process." He has a follow-up question: exactly how are new gen reactors safer when it comes to meltdowns and how are they protected against tsunamis and missiles? Julia, I'm going to turn this one back over to you.

Julia

This is a great question. We talked a little about this on episode five when we discussed advanced reactors and the new passive safety mechanisms they're building in. Unlike the pressurized water reactors that have come before, Fukushima for example, those required external power to control the systems that would prevent a meltdown from happening. This is actually what caused the accident at Fukushima. The tsunami flooded the area where they had the backup diesel generators. The power went down and therefore the core was not able to be managed. We saw the meltdown occur.

That's the big difference here, these passive safety mechanisms, where you don't rely on that external power. As for tsunamis and missiles, the big difference is the fuel that will be used by the new generation reactors called TRISO, which we mentioned in the previous episode as well. These are small silicon carbide coated uranium mini pellets, like the size of a poppy seed, designed to withstand kinetic impact.

Instead of kinetic impact causing some sort of emission of radiation and radiation release, you have these silicon carbide coated pellets, which is one of the hardest materials in the world, think diamond strength, that hold in the fission products and are much more resilient against any sort of kinetic impact.

Packy

He also asked about the regulatory approval process. The point on TRISO is a good one.

Do we have a sense of whether, in the regulatory approval process and the clearance space around a plant, TRISO is going to be able to replace many of the extra built-in constructed safety requirements that protect

against being hit by a 747?

Julia

Yeah, it's a great question. TRISO has been developed with the DOE, so it's been sort of government-blessed along the way, which is very helpful instead of something new coming out of industry. It's got that level of approval thus far. Although to my knowledge, we're not commercially using TRISO anywhere yet and it has a very nascent supply chain.

As far as that safety zone or exclusion zone around the plant itself, the NRC, to their credit, actually approved a design from one of the SMR companies that allowed them to have a smaller exclusion zone. So a smaller safety security zone around the plant, because they agreed that this smaller form factor reactor shouldn't require the same amount of space around it. People were very excited to see them make a good common sense decision that was moving our industry forward.

Packy

We're not asking for a lot, just some good common sense decisions.

Julia

Exactly.

Packy

That's great. And then I guess our last one here, from an anonymous DM I got from a super talented young person interested in getting into nuclear. He asked, "What are some ways to get involved in nuclear? I'm passionate about it, but not sure how to make an impact."

He has a very impressive PhD in machine learning from Stanford. So I guess the better way to ask the question is: what are ways for generally really smart young people to get involved in and make an impact in nuclear?

Julia

I love this question. There are a few ways to get involved. One is to work in the industry. Go work at a company, maybe one of the new advanced reactor startups or a more traditional firm. There are plenty of roles, just like any company. You might be an engineer, but you could also work on the PR team or something else. So there's the commercial route.

There's also the think tank/nonprofit route. Several organizations, such as Clean Air Task Force, Third Way, and Clearpath, are pro-nuclear and looking for people to join their policy and research teams. Finally, you can get involved with advocacy. Several organizations welcomed me with open arms, taught me what I didn't know, and gave me exposure to state-level legislating and organizing to inform leaders about nuclear and how they can change policy to be more supportive.

I'll turn it over to Heather Hoff now, who leads Mothers for Nuclear. I have a great t-shirt that says 'Mothers for Nuclear' which probably raised a few eyebrows. Heather works at the Diablo Canyon nuclear power plant in California. I'll let her talk about starting Mothers for Nuclear.

Heather Hoff

I'm Heather Hoff. I run a pro-nuclear advocacy group called Mothers for Nuclear. A common question I get is what people can do to support nuclear energy and be more involved in the pro-nuclear movement. There are many great answers to this. First, there are many different types of advocacy groups for nuclear. Generation Atomic is one of them. They have a great map on their website of partner organizations around the country and the world that you can join. Monitor their newsletters, read and share their social media.

Wearing pro-nuclear merchandise is another way to show your support. If we're going to build new advanced nuclear technology in the next generation, we need to show our policymakers that there is public support. One of the best ways to do that is to have an outpouring of support on social media, sharing stickers on your phones, computers, and electric cars. "Split, don't emit" is one of my favorites. All these things can help demonstrate that normal people like you and me support nuclear energy.

Julia

So great to hear from Heather. I also want to turn it over to Paris Ortiz-Wines. She's the global director for the organization Stand Up for Nuclear.

I reached out to the Stand Up team cold via the Internet, and Paris invited me to join her group that meets regularly to discuss areas where they can get involved in championing nuclear.

I'll turn it over to her to talk a little more about Stand Up.

Paris Ortiz-Wines

My name is Paris Ortiz-Wines, and I am the global organizer of Stand Up for Nuclear, a global initiative that advocates for the protection and expansion of nuclear energy. I love this question of how to make an impact and get started. There are two things you can do.

First, get acclimated with the energy conversation. What are people saying about nuclear? What are they saying about energy in general? We have to know these things to be effective communicators and see where we need to push and pull with this issue. Here are a few resources to look into: The Breakthrough Institute, which has great thought pieces on energy, nuclear, and policy; Decouple Media podcasts, covering nuclear energy, energy in general, solar, wind, and grid complexity - many of our advocates that we have in our network have been featured on that podcast; and Electricity Maps, which shows where our power comes from day-to-day, every hour, in your location or region. It's free, and many advocates use it to fact-check greenwashing statements like "we ran on 100% renewables", and we can check day to day with the data.

Second, connect with people already in the space. There are numerous pro-nuclear organizations focused on advocacy: 1) Stand Up for Nuclear: Reach out to us to get involved and connect with others. 2) Mothers for Nuclear: An established nonprofit in California since 2016, instrumental in the fight for Diablo Canyon. 3) Generation Atomic: They've done great work on nuclear energy and policy, with easy actions many people can join. 4) Nuclear New York: State-based, uniting climate and union groups. Take a look at these resources, familiarize yourself with the energy conversation, make connections, and follow some of these people on social media.

We're on Twitter and have lists of US and global allies. Remember, advocacy covers a wide range of activities, so don't be intimidated. Good luck!

Packy

I love the idea of getting involved in advocacy, and I think it's well-timed. We wanted to do this mailbag kind of episode. We missed Thanksgiving Day itself, so you're not going to be able to bombard people with this information at your Thanksgiving table. But hopefully, you're still with your families and friends from home, having conversations about what's interesting to you recently.

Spread the word. As we've been saying all season, we want this to move outside of tech circles. I think tech people now generally agree that nuclear is a great thing. We need to make it cheaper and have better regulation. But wherever you are in the country or the world, tell your friends about nuclear, why you're excited about it, and what they can do.

Julia

Yeah, and the holiday season continues into December, so plenty of opportunity coming going forward.

Packy

Julia, have a great rest of your Thanksgiving weekend. I hope you enjoy your leftovers.

We'll be back for Episode 7, where we let a bunch of really smart people tell us why we're wrong and why other energy sources are going to be the winners.

Julia

Thanks Packy. I'm looking forward to the next episode.

Packy

Thank you for listening and watching to this episode of Age of Miracles. If you like what you hear, please rate, subscribe, and share. And if you're feeling really generous, tell us what you think in the comments.

Plus, we have a ton of resources and references in our resource hub if you want to go deeper. And we've linked them all in the show notes below. See you next week.