



Episode 10

Energy for an Age of Miracles

Matt Slotkin

There's a quote I quite like from Alan Kay, who ran Xerox PARC: "The best way to predict the future is to invent it." I think that, especially right now, this is such an exciting, important time where the future could be one where we all have to consume a little less energy. We've kind of maxed out our per capita energy, and we say, okay, now this is the amount that we're all allotted, and let's just make it clean.

Or it could be one where we say, actually, why are we content with that? Let's 10x or 100x that. What does the world look like then? There's no future to be discovered. It's not like it's already been pre-written and we're going to figure it out. It's up to people to make the future we want it to be, or to at least try.

Packy

What a perfect quote to kick off the last episode of this season of Age of Miracles. That was Matt Slotkin, the founder of Blue Energy. The company plans to build nuclear reactors in shipyards, put them on boats, and float them to end markets around the world.

"The best way to predict the future," Matt said, "is to invent it." That's a good way to summarize the point we've been trying to make this season. We can live in an age of miracles, but it's going to take a lot of work.

Julia

Energy is kind of like the meta version of that idea. The world is in the middle of a transition to cleaner, more abundant sources of energy, like nuclear fusion and solar, and as we've covered throughout the season, it's incredibly hard to pull off. Of course, there are the technical aspects. Figuring out how to unlock the energy latent within atoms is one of humanity's greatest discoveries to date. But the discovery is just the starting point.

Between innovation and impact, there is a gauntlet of opponents, regulators, construction challenges, financing costs, supply chain issues, public sentiment, and setbacks. On the other side, though, if we figure out how to overcome all of the hard things standing between us and widespread nuclear fission and fusion energy production, all of the other really hard things we want to pull off will become a whole lot easier.

Packy

That's why we chose to do the first season of Age of Miracles on the energy sources of the future. In the first episode, we said that energy is at the root of prosperity and progress, and I believe that even more strongly after working on this season. If a genie gave me the ability to plant one idea deeply in the minds of everyone in the world, I might choose that one.

Energy abundance is the most important thing we can work towards as a species. More than simply surviving climate change, we have the opportunity to unlock a new level of human thriving if we can successfully navigate this transition.

Julia

Fortunately, the world seems to be waking up to this idea. On episode six, we mentioned rumors that the US would lead an international coalition at the COP 28 climate summit in committing to triple nuclear capacity around the world by 2050. A couple of weeks ago in Dubai, that happened. Nuclear wasn't even on the table at these summits a couple years ago, and this year it was the main event.

Michigan governor Gretchen Whitmer recently put out a video saying that her state was working with private and public partners to reopen the shuttered Palisades nuclear generating station. She said, "Going forward, nuclear energy will be a piece of our clean energy strategy." International agreements and pro-nuclear statements don't put gigawatts on the grid.

The ITER project is proof that even with the best intentions and biggest budgets, these projects can take a lot of time. But popular support is a prerequisite to production, and popular support is certainly shifting in nuclear's favor.

Packy

The momentum feels even stronger than it did at the beginning of the season just ten weeks ago. But turning that popular support into power is going to require a sustained effort from thousands of people over the next decade and beyond. On the fission side, utilities will need to order Westinghouse AP1000s first one at a time, then five at a time, then ten at a time, and take advantage of the talent trained and lessons hard won at Vogtle. Small modular reactor companies like Oklo and Nuscale will need to deliver on the opportunities they've been given and earned.

We'll need to see the developer model come to nuclear in force to make building reactors large and small more efficient. On the fusion side, private companies will need to prove that they can achieve $Q>1$, then prove they can achieve a Q high enough to economically capture and sell the energy released in the fusion reaction. Fusion is less impossible than it seemed a few years ago, but a lot still needs to go right.

While we didn't cover all of the challenges that lie ahead, I think you can learn a lot by perusing the YouTube comments of our fusion episodes. I've been struck by how smart and thoughtful a lot of the conversation there has been. We'll also be releasing bonus episodes featuring some of the full-length interviews we've done this season, so keep an eye out for those.

Julia

One thing that fusion has on its side that fission doesn't is a cleaner regulatory framework. In this phase, when engineering is becoming as important as physics, the iteration speeds possible in fusion will be hugely important. Given the emphasis on building things, seeing what works, and tweaking that we've heard from companies like Helion and Zap Energy, it's hard to imagine that we'd achieve fusion in this century if it faced the same regulatory challenges that fission does.

While commercial fusion is going to be incredible when it arrives, and while we think it might arrive sooner than we expect, it is crucially important that the excitement over fusion doesn't drown out the growing excitement around fission. As one YouTube commenter, chapter4travel, said, "There is nothing that fusion promises in some fantasy future that fission can't do today." The language is stronger than we'd go for, but it has some truth to it. Nuclear fission works today. It's clean, safe, and the fuel is abundant. If the world had 10x more nuclear capacity, it would be in a much better place.

On episode five, we talked about paper reactors versus practical reactors. Currently, fusion generators are paper reactors. On the hand, fission reactors, which provide almost 20% of the US's electricity operating in 28 different states, are practical reactors. They are actually producing power.

Packy

That's a really good point. Fusion will face challenges that will only become evident once companies achieve $Q>1$ and start building real power plants. Fission has already faced every challenge in the book. There have

been anti-nuclear movements, meltdowns, stringent regulation, construction delays, supply chain challenges - you name it, fission has faced it. But despite all of that, the technology works. We need to do everything in our power to bring more of it online now.

While we spent a lot of time this season talking about all the challenges besides regulation, and while nuclear founders are hesitant to place the blame on regulators, I've come away more convinced that the biggest bottleneck to nuclear's development is regulation. Everything else - construction delays, expensive materials, high financing costs - would be improved by more sensible regulation that prioritizes safety but thoughtfully weighs the costs and benefits of nuclear, as opposed to simply minimizing the risk of any costs at all.

The most surefire way to minimize the impact of nuclear waste or the risk of meltdowns is to make sure that no new nuclear gets built at all. And that's what the NRC has effectively accomplished. But that's also the most surefire way to ensure that people die from much more dangerous fossil fuels, that we continue to increase the temperature of the planet, that companies rely on foreign oil, and that we remain stuck in this current energy regime. Put bluntly, the benefits of nuclear far outweigh the costs, which have been overblown. And we are not taking climate change or energy abundance seriously until we make it easier to build new nuclear capacity. So what can you do about it?

Julia

So what can you do about it? It's becoming less and less risky for politicians to support nuclear energy. I think the best thing listeners can do is to lean into that momentum and push their representatives to support nuclear. We need to generate the political will in this country to overhaul the way the NRC operates. That starts with ensuring that Part 53, which deals with the regulation of advanced reactors, enables the very innovation that can make reactors safer, gives clear guidance to companies innovating in nuclear, and gets enacted as soon as possible.

But ideally, it would mean revamping the way the entire NRC regulates nuclear, from the smallest reactor to the largest. I like a 16z American Dynamism partner David Ulevitch's idea here.

David Ulevitch

So if we talk about the future, I think government's role is to create incentives and motivations if they want to change the composition or size of that pie dramatically. That would be an incredible place for government to play a role. They can do that through legislation and funding. I don't think it's just tax credits.

Julia

Instead of preventing nuclear, the government needs to view it as one of the most strategically important assets the country can produce and export, and mandate that the NRC issue licenses. We've talked about whether capitalism or authoritarianism works best for nuclear, and I think the answer is capitalism, unburdened by the practically authoritarian restrictions we've put on the category. So call your representatives. You can find their contact information at House.gov using the "Find Your Representative" tool and entering your zip code. Tell them that you support nuclear energy or join a nuclear advocacy group. Some favorites are Mothers for Nuclear, Stand Up for Nuclear, and Generation Atomic. Vote for pro-nuclear candidates. Turn the disparate trickles of nuclear support into a wave.

Packy

Amen. I'm not a single-issue voter, but I really think energy is one of the few categories that, if you get it right, can solve all sorts of other issues we just spin our wheels on today. A couple of weeks ago I wrote about why I think the climate crisis is actually a useful thing, in that it's a forcing function that will push us to unlock the next level of energy after fossil fuels. The important thing for humanity is having the ability to produce and consume much more energy without killing ourselves in the process. And that's exactly what fission and fusion promise.

One thing I realized writing that piece is that humanity is only as ethical as it can afford to be. The US and Britain abolished slavery after the industrial revolution made it economical to replace human labor with machine labor for many jobs. I think there's something more broadly true there. When food was scarce, it was acceptable

to kill neighboring tribes to take their food. When machine labor was scarce, it was acceptable to enslave other human beings. Today, we allow billions to live in energy poverty because fossil fuels are a scarce resource. Around the world, children still do homework by candlelight once electricity goes off for the day. Think of all the human flourishing capped by lack of energy.

In the future, if we look back on farming and eating animals as barbaric, it will be because we've learned to convert energy into food as delicious and nutritious as meat. We may look back on people being forced to spend most waking hours working jobs they hated to provide for their families as horribly unethical. Once we can afford to, we will certainly view energy poverty as unethical. One main reason we progress in energy is to afford to become more ethical. If we figure out energy, we get all sorts of other good things, practically for free.

Julia

We can talk about how energy-dense, clean or safe nuclear is. Throughout the season, we've given statistics and specifics to make the case for producing more nuclear energy and fusion once it arrives. But energy for Westerners is like water for fish. It's just there. This is Packy's analogy, and I love it. We are David Foster Wallace's fish.

There are these two young fish swimming along, and they happen to meet an older fish swimming the other way, who nods at them and says, "Morning, boys. How's the water?" And the two young fish swim on for a bit, and then eventually one of them looks over at the other and goes, "What the hell is water?" We flip a switch and electricity just comes pouring out. If we need to drive somewhere, we fill up our tanks and hit the road. The best possible outcome for energy is that you never have to think about it, because it just works and doesn't limit anything you want to do.

So to end this season of Age of Miracles, we wanted to leave you with specific visions of what the world looks like when we have abundant energy.

Packy

Thanks for listening so far. Hang on, we'll be right back after a quick word from our sponsors. At the beginning of each interview, we asked people what the pie chart of energy sources looks like in the US in 2050. We shared some answers in episode seven, when we covered other energy sources people are excited about besides nuclear. And we want all of them - nuclear fission, fusion, solar, geothermal, hydro, and yes, even wind.

At the end of each interview, we asked every guest: "What does the world look like when we have abundant energy?" The answers highlight why getting this transition right is so important, how more energy will impact people's everyday lives, and why we chose to do the first season of Age of Miracles on nuclear and fusion energy. So we're going to let you hear our brilliant guests' specific visions of our abundant energy futures straight from them, starting with Josh Wolfe at Lux Capital.

Josh Wolfe

If you ask me, the single most important concept to understand is entropy. The way you fight entropy, the natural trend towards disorder in thermodynamics, is by putting energy into a system. It's true of our human body, our relationships, companies that need capital, society at large, and even your room. These things trend towards disorder. The way you stop disorder and create structure is by putting energy into systems. Abundant energy would reduce entropy and create progress.

When you see old visions of the future, like in SimCity, it was nuclear reactors with monorails and flying cars. Nuclear power gives you that elemental energy. If you have abundant energy, you can desalinate water. We have abundant water, but 98% of it has too much salt. Desalination, whether through reverse osmosis or other methods, is very energy intensive. But with cheap, abundant energy, you get abundant water. With abundant water, you can irrigate places that don't have arable land. Arizona and Southern California spend so much on watering gardens and pools. Then you've got agriculture and healthy food. And you can spread that to the world.

To me, that's the virtue: abundant energy, abundant water, abundant food. If there's a clean source of electricity, then let there be a million electric cars, whether they're Elon's robo taxis or Audi, BMW, Porsche,

Toyota, Honda, GM, or Ford. We will have electric cars. We will have far fewer roadways, and people will have fewer parking spots. There will be more green inside cities. I think cities are generally getting greener for various reasons.

Manufacturing becomes a playpen for people with abundant energy to tinker and experiment. Transportation costs decline. It's a beautiful world, and it's elemental.

Julia

Clean water and green spaces.

Here's Terraform Industries' Casey Handmer.

Casey Handmer

More energy is better, particularly carbon-free or carbon-neutral energy. This is how we extend the wealth that you and I enjoy to 8-10 billion people, plus their friendly AIs. This is how we finally put most human needs below the API. One interesting case for expansion of hydrocarbon consumption is aviation. Currently, aviation consumes about 2% of the global hydrocarbon supply, which itself is roughly a \$7 trillion per year industry.

Just since we've been talking, the global oil and gas industry has turned over a billion dollars. There's a mindset that says to solve the carbon emission problem from aviation, we need to compel a carbon tax to pay for offsets, which are kind of rubbishy. It's not controversial for me to say that. They also want to increase the price of flying to make it more exclusive. So, screw poor people. You get to go nowhere or go someplace slowly. You have to spend your limited hours before you die sitting in some shitty slow bus or train. I don't like that mentality at all.

I think we should be like, "We figured out how to make synthetic fuel, and by the way, it's 10% denser than kerosene, so planes can fly further, and it's also half the price." Now, instead of 10 million people routinely flying planes, it's 100 million. Because it's so much cheaper, we can get back on the supersonic transport bandwagon, which fizzled out with Concorde because kerosene got expensive. It's a super exciting future if gasoline is durably a buck per gallon anywhere on earth. Maybe it's a little cheaper in equatorial areas, which is nice for them.

Ten million people like you and I who fly planes routinely get to fly supersonically. I can go to Australia in 4 hours instead of 12 or 14, and another billion people can fly around the world for education, work, meet loved ones, just have a better and cooler life. Obviously, we can spend fuel flying people to other planets as well. But that's a drop in the ocean. The number of people you have to fly to other planets to make a dent in global hydrocarbon usage is staggeringly high. I hope it comes true, but it'll be a while yet, that's for sure.

Packy

This is what I mean by saying that solving energy makes all sorts of other problems easier. If we figure out energy, we can figure out supersonic flying again. We can go to Japan to get sushi.

Here's Angelica, one of my favorite interviewees throughout the season. She was such a good sport; we asked her to support wind, and she ended up supporting nuclear and telling us what the world looks like if we get that right. It's straight out of sci-fi.

Angelica Oung

There are Star Wars people and Star Trek people, and I'm very much a Star Trek person. When you watch Star Trek, especially The Next Generation, you see a society that has transcended material squabbles. They've gone post-scarcity, post-economics, and there's still an infinite amount of exploration to be done, lives to be lived, arts to be created, but they're not constrained by their next meal. They're not constrained by pressures that stop them from living life to the fullest.

I think about how right now in the world, there are people living lives that are so much more constrained than my own. In third world countries, they might not be able to study or girls might not be able to reach their full

potential because they're tied to the drudgery of washing laundry by hand. The easiest metric to determine whether they have good lives is power usage. You see that the poorest countries use so little power compared to the rest of us.

I've just come back from the Philippines, a country with enormous potential and a very skilled and desirable workforce. We know that because Filipinos go all over the world to work, as they don't have opportunities in their home country. While there are many factors for this, one big one is that the Philippines, as an archipelago nation, doesn't have a stable grid, and power is not just expensive, it's unreliable. The potential of that country can never be fulfilled without cheap, stable electricity.

I believe that's also broadly true all over the world. The rich world needs nuclear energy to decarbonize, and the poor world needs abundant, affordable nuclear energy to thrive. Right now, nuclear energy is low carbon, but it's not cheap and abundant yet. We know that's not a physical impossibility. We just need to find a way to get over our fears and engineer a way to make it so. And I believe in our human ability to do that.

Julia

Next, here's Alex Epstein, the author of "Fossil Future."

Alex Epstein

If you love energy, you should be really excited by what we can do if there's way more of it. If it was so cost-effective that energy use ended up multiplying by ten, let's think of a few things. One is that everyone could actually be prosperous. I think the life of the average person around the world, if most of us got put in their position, we would consider it to be the apocalypse. We go without power for a few days, and we think the world is over. That's a normal thing for many. It's hard to talk about what it's like if you really think concretely about not having reliable electricity. I talk in my books about what it's like to not have incubators when you have a premature child. That child dies, and in the United States, you don't even think about it much later, yet it's a permanent tragedy for millions of people, happening all the time. Life could continue progressing, and billions of people would have better lives. I think that's better for everyone, but certainly better for them. So one is that people can actually rise out of poverty. Another is medical care and longevity. A lot of what we have now in terms of medical care and longevity is based on having really cost-effective energy, in part because we have amazing machines that use a lot of energy and take a lot of energy to produce. The cheaper those get, the better. A huge aspect is now, as we have augmented intelligence with machines, we have a potentially unlimited amount of compute desirability to discover new things about health. It'd be great if you just had five times more energy at your disposal. If there's something really difficult to figure out, you can totally invest in that.

More broadly, you can invest infinitely in knowledge, or in being aided in gathering knowledge. That, in a sense, is going to be in every field, but just medicine in particular I think about because I'm 43 right now, and I'm definitely going to die at some point. I'm not one of these people who thinks I'm going to live forever, but it'd be great to extend that by 10 or 20 years, and it'd be great to be healthier during that. One of my sentimental favorites is macroclimate mastery. The higher ability you have to neutralize climate dangers and harness climate benefits, the less relevant your particular climate is. This is why in the United States, we can all have a life expectancy around 80, despite having polar Alaska, swampy Florida, Texas - all these crazy climates - and we're totally good in all of them because we have a high level of mastery. But if you look at our mastery, we want that to spread around the world and be cheaper. Right now, poor people around the world, even in the wealthy world, have real trouble air conditioning their homes and heating their homes in the winter. These are still existential problems for people. We want that to improve radically. Obviously, we're going to want to change our local climates for the better on a more macro scale. Right now, most of our mastery is creating resiliency in our own structures and capabilities so that we can deal with dangerous changes in our atmospheric surroundings, which is a constant in human life. But what if we could neutralize the hurricane? Or what if Texas wasn't so damn hot to live in for certain months? Why can't we cool ourselves? And then on the global level, as we learn more about climate, we might decide, here's a better level of CO₂, or here's a better average temperature. I think ultimately what people want to do is going to be more local. On the global level, some of those things don't take a lot of energy, like putting certain particles in the atmosphere. But I'm guessing a lot of the local stuff will.

Then the final thing, which I think is also underrated, is just ubiquitous fast transportation on demand. You only have a very limited amount of time on earth. It's very limited. And there's a lot of really cool stuff depending on what you like to do. But almost anything you like to do, if you could really quickly get anywhere on earth, you could have a much cooler life. You could think of anything you like, like different sporting events, you want to see different parts of history, you want to be inspired by different things, you want to connect physically, you just want to be around different people. All of these things can be dramatically improved by rapid, cheap transportation. There's just so much stuff here, and that's just going to take a whole lot of energy. But that's exciting. You can imagine a world where it's just much more enjoyable because you're able to travel to all these amazing places and be around the people. And I'll just say that I really only align with people who are excited about energy abundance, regardless of how they think we're going to get there. And I think we have a real tragedy, which I'm glad that you guys are countering, that there's this embrace of energy scarcity where people think it's okay that we have chronic electricity shortages. They think it's okay that Texas has warnings every day during the summer about electricity. They think it's okay that people are trying to ban short haul flights in Europe, like, "Hey, why do you need such convenience? Take a longer amount of time." This is embarrassing. We should be embarrassed by regression because we have all the raw material. We have more ability to acquire knowledge than all the raw material, to have abundant energy. We have more knowledge than ever. And it's only our bad ideas and policies that are holding us back. I'm so alienated by people who see regression or even non-enthusiasm for progress and who think, "this is okay. I don't mind this." And that's sad for them. I mean, it's depressing that they think of themselves that way. But then if you think about the fact that most of the world is just incredibly poor, and you're okay with that continuing, then that's a really perverse view. So I was excited to talk to you guys because you clearly stand for real energy progress. That's what we should all be talking about. And unfortunately, that's talked about less than 1% as much as "let's get rid of our climate impact", which even if that was necessary, is not an inspiring goal.

Julia

I love that we end with all of the people we talk to and their vision for an abundant energy future. Kind of where our whole journey here began. Packy, when we started working on this, we said, "why do we even care about energy? You just flip a switch and your lights work. It's no big deal. We got energy. It's cool."

But you realize how much the rest of the world is held back by lack of energy. Imagine spending all your day gathering firewood just to cook your dinner. But we sometimes forget that our own potential in the western world is still hampered by lack of energy. We could be doing so much more. Our quality of life could be so much further improved.

We know that the cost of everything we do and make is rooted in energy. So as soon as you're able to bring that cost down and have more abundance, everything else gets better.

Packy

Amen. I was listening to "Live Players", the show that Erik and Samo Burja are doing. Samo had an interesting point: what's holding energy back, including nuclear and solar, is that there's not enough demand for energy. So it makes the economics not work. He said if there's a population 100 times larger than the United States, the economics of a nuclear plant would make all the sense in the world.

To me, that sounds like a challenge to get more ambitious about what we want to do with our energy. Energy is a thing where if it gets cheaper, you use more of it. So maybe another ask is to think about all the things you might want to do if you had access to unlimited energy. Iceland consumes two or three times more electricity per capita than anybody else in the world. They also happen to have 20% of their population as millionaires now. They do aluminum smelting and have data centers pop up there. There are all these things they can do because they have all this free geothermal energy. That could be all of us. We could do things so cheaply that we can just build easily, export them to the world, and make people richer.

So I think Samo's point was maybe a challenge to all of us to get more creative with what we want to do with our energy. We talked about it earlier, but there is so much momentum right now. All this stuff sounds sci-fi and futuristic, but it feels like it's within our grasp. We talked a lot about how the NRC is very slow to approve new designs. We actually got a breakthrough there this week, didn't we?

Julia

I know. It's awesome that we're wrapping the season with a fantastic milestone from the NRC. They've been notoriously slow in licensing new reactors, but they just announced that they've approved the first advanced reactor license in half a century. This is really exciting. It's the Kairos Hermes reactor. Granted, this license is for a test reactor, but it's still progress.

I love to see it. I think the NRC is feeling the heat. They're feeling the pressure of all these companies building great stuff. Now they're the blocker and they've got to unbottleneck all of this. So I love to see it.

Packy

It's amazing. Isaiah made that point in one of our conversations where he said that you could talk about badgering the NRC, but what we really need is for entrepreneurs to get out there and build stuff that's worth changing the regulations for. So it's cool to start seeing that happen. One of our inspirations for doing a narrative podcast was Serial. Not that we did anything like Serial or talked about a murder, but this idea of having a story that fits within a season. That one ended on a cliffhanger. We didn't know whether Adnan was guilty or not.

The fun thing about this one is we tried to put as much information and story in one season as we possibly could. But this thing is very much ongoing. Definitely follow Julia on Twitter to see what happens at Antares and follow her sharing things in nuclear. Definitely follow some of the guests. I've particularly enjoyed following Nick Touran on Twitter. It's a mix of modern news and old-school nuclear diagrams. He's a great follow at @whatisnuclear.

This story is still ongoing. We're going to release full episodes with some of our favorite guests throughout the season. Hopefully this isn't the last you hear from Julia and me on this topic. We will be doing an Age of Miracles season two on a new topic. I'd love to hop back on with you in the next few months and give people an update on what's happening in nuclear, because it feels like stuff is happening at a really rapid pace for an industry that has moved so slowly for such a long time.

I think it's fun that now I feel like I have the knowledge to go out and see what's happening in the news and actually contextualize it and understand what's going on. That was one of the big goals of this season for me, to at least give that base for this thing that I think is going to be so important going forward.

Julia

I feel like we should wrap it up here by turning it back to Julie Kozeracki from the DOE. She's got a great quote here on reaching our potential, so I'm going to turn that over to her.

Julie Kozeracki

We are in a very special moment right now that won't last forever. So my last point is that we cannot wait. We've got some really incredible legislation that happened. We have an extraordinarily supportive administration.

There's been a lot of focus on nuclear in particular. So I hope that folks don't let the moment pass, and I hope that they lean in, take a big breath, and set us on a path to actually realizing our potential.

Packy

Man, what a great quote to end the season. Someone in the government who wants to make a change, telling us to go out and actually realize our full potential. That's what we're all about here on Age of Miracles.

Julia, I've had a blast doing this. I could not have navigated this crazy space without you. Thank you so much for doing this with me. I couldn't have asked for a better cohort.

Julia

It was such a pleasure, Packy. I enjoyed it so much and I can't wait to see where you take the podcast next.

Packy

So stay tuned for updates on season two of Age of Miracles. Certainly stay tuned for updates on what's happening in the world of nuclear. Thank you so much for listening to this first season of Age of Miracles.

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