The Nuclear Option

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Greg Dalton: This is Climate One, I'm Greg Dalton.

Ariana Brocious: And I'm Ariana Brocious.

Greg Dalton: Fourteen years after receiving its permit, the nation's first new nuclear reactor in decades just fired up in Georgia.

Ariana Brocious: And they ended up costing over 30 billion – more than twice the initial projection – hardly a success story. But that's the reality of the current nuclear power industry in the United States.

Greg Dalton: That's true. Huge, traditional nuclear reactors like the new Vogtle plants have faced so many cost overruns and construction delays that new ones aren't economical in competitive power markets.

Ariana Brocious: Several companies are exploring new technologies, often collectively referred to as "advanced nuclear," to try to find better ways of getting at the carbon-free promise of nuclear fission. But a lot of that is still on the drawing board.

Greg Dalton: That's even more true for nuclear fusion, which has had some promising advances in the lab recently. But nuclear fusion is still decades away and we need to decarbonize the global economy faster. So we are leaving fusion aside and talking about fission, which provides about 10 percent of global electricity supply.

Ariana Brocious: In developed countries nuclear is waning as old plants are being shut down. And as we talk about on today's show, it's unclear if a promised new generation of reactors will prove significantly safer, cheaper or more useful. Former Nuclear Regulatory Commission chair Allison MacFarlane:

Allison MacFarlane: I don't think there's gonna be some magic or miracle that's gonna happen that's going to vastly improve the nuclear industry.

Greg Dalton: Nuclear power is a polarizing subject. Some enviros are dead set against it because of the risks of radioactive leaks. And though it's carbon free, many question whether nuclear can really be considered clean energy. Radioactive waste lasts hundreds and hundreds of years, and we still don't have a permanent way to deal with it. There's also concerns around nuclear weapons proliferation if the materials and technology used for peaceful energy production get in the wrong hands.

Ariana Brocious: Yeah. These are major risks and considerations when we talk about current or new nuclear power. But other climate experts say it's not fair to judge the industry solely on our current fleet of reactors – those were mostly designed over 50 years ago. And people like MIT's Jacopo Buongionrno say we need ALL forms of carbon-free energy to slow the ongoing climate disaster, and if we want to have any hope of reaching net zero carbon emissions by midcentury.

Jacopo Buongiorno: There is no silver bullet here, folks. The magnitude of the problem is so high that we need to push on all technologies that we know work.

Ariana Brocious: So, on today's show: The Nuclear Option. Up first, my interview with Melissa Lott, Senior Director of Research at the Center on Global Energy Policy at Columbia University.

Nuclear energy has been back in the news lately. We have to power our renewable energy future. So there's a lot of concern about where that power is gonna come from for carbon free energy. And on the other hand, since Russia's invasion of Ukraine, we've been hearing about threats to the Zaporizhzhia nuclear power plant there in Ukraine. And there've been some recent headlines around Japan's release of water from Fukushima, like, "is your sushi safe?" And those kinds of things. So, what's your reaction when you hear those stories?

Melissa Lott: When I hear all the different stories, I come back to, I guess three main principles. Like one, we're looking at decarbonizing our energy systems to mitigate climate change and also adapt to the change we're already seeing. And so within that, number two, what technologies do we have? What do we need to make sure that it's reliable, affordable, and clean? So all three of those things at once, within that nuclear is one of the few technologies that we have access to today that can provide something called firm dispatchable power. And so the third thing I think about is, okay, given that we have nuclear, geothermal, a couple of other things. What are the trade-offs that we are willing to accept in different parts of the world? Because when we think about the resources we have and the trade-offs and priorities that we have as individual communities, states, as nations, the answers end up being different. And so within that, nuclear is one of those technologies that provides potentially a really valuable service. It already does today. And could in the future.

Ariana Brocious: And I just wanna explain for people, I think some of our listeners will know what firm dispatchable power is, but for those who don't, I mean, we're talking about the benefit of having something that can be on all the time, right? Nuclear can do that. Coal can also do that as opposed to something like solar and wind, which are not always available. Is that fair?

Melissa Lott: Yeah, so the idea with nuclear power or when you're talking about a net zero world, you could talk about coal or natural gas with carbon capture or geothermal or really big hydro, is that it could operate 24/7, 365. It's there when you need it and you can attach things to it. So you can have a nuclear power plant with some short or long duration energy storage that could make it be able to kind of effectively ramp up and down, but the idea is it doesn't go away when the sun sets or the wind stops blowing for a period of time. So it compliments wind and solar and also energy storage technologies. It's one of the players on the field that you want to have a winning team.

Ariana Brocious: So we'll get into some more of the concerns around nuclear in just a second, but back quickly to Zaporizhzhia and Fukushima. These two are relatively old designs of nuclear reactors. Give us a sense of what is the current sort of state of reactor design.

Melissa Lott: Yeah. So one thing that I run into a lot in these conversations is a belief that the future of nuclear looks like the past. And what we've seen is we've actually made a lot of different improvements in different types of nuclear technologies. So there's a couple of different good resources for folks who wanna dive deep into the technology on it. But at a high level, I think about water-cooled reactors and non-water-cooled reactors. So these advanced reactor designs. And so water cooled reactors, it's what you say on the tin, you know? But when you go into those advanced reactor designs that are non-water cooled, that's where you start hearing things like salt and sodium-cooled reactors, high temperature gas-cooled reactors, gas cooled, fast reactors, and micro reactors. And so I think of the future of nuclear in two broad buckets. One is technologies that have improved and advanced since the stuff that we installed, you know, in the past decades but is still really big. These huge centralized power plants that produce massive amounts of electricity. They have tons of wires going into them. And then the smaller reactors that we may deploy in different applications where it makes sense to maybe not have this huge power plant anymore, but have something smaller. So something that is more scalable.

Ariana Brocious: For someone who's not well versed in nuclear, why do you have to have cooling? Why is that a piece of the generation?

Melissa Lott: So when you think about the nuclear reactors that are running today, so two things. They're nuclear fission, which means breaking things apart. What you end up doing, like you do in a coal-fired power plant or a natural gas fired power plant, is you end up producing heat. And so within that, you need somewhere for the heat to go. So you use the heat to actually boil water, to turn the turbine, so to create steam, et cetera, et cetera. And overall you need, you still have heat left over after that process. You use the really high, high, high temperature heat. The really high quality is what we call it is engineers heat, but just the really good stuff, the extreme stuff, you use that to generate electricity, but then you're still left with a lot of stuff that is still really, really warm. As a person, I would still call it hot. And so you have to figure out a way to get rid of that, and so you have water that you will run through it in order to actually cool your steam down so that it becomes water again, so you can put it through your system again. So what it is really is making sure that your heat goes to a safe place. So first, use some of your heat to produce electricity, and then you need to get rid of your excess heat so it doesn't end up staying in problematic places.

Ariana Brocious: So how do these newer, small, modular reactors, which are often abbreviated to SMRs, differ in their design from the larger traditional reactors?

Melissa Lott: So right now, when we think of building a nuclear power plant, it's one big thing. It may have a couple of reactors inside of it, but it's this huge power plant. We are talking about with SMRs, these smaller components that if you need more, you can build more and have multiples. But if you need less, if you just need a little bit of firm dispatchable power to compliment whatever else you have in your system, you can do that. A lot of them are light water reactors, so you actually use water to again transfer heat. Depending on the design, you may use much less water, because we have learned a lot about how you more effectively remove that heat that you know you don't want in certain parts of your system and put it to other places where it's safe and where you can contain it.

Ariana Brocious: So it seems like there's a lot of excitement around the possibilities that might be available from these small modular reactors. Earlier you said, we need energy that is reliable, affordable, and clean, but what about safe? And are the advances in some of the new technologies around nuclear significant enough to make them safer than older technologies?

Melissa Lott: If you break it down into a couple of different things, how I think about it is, that's what you want in a nuclear power plant to make sure that it is safe, is that anything going wrong, anything at all that goes, not exactly how you might have wanted it to in an optimized system, results in things safely shutting down. So you want anything that could possibly go wrong to give you a negative feedback loop. So it's like, oh, that's not exactly within spec, we're gonna wind down and safely turn off. Like that's what you want in all your designs. And so we've gotten really good at figuring out what are the different things in our systems that could potentially, you know, a fuse blows, you know, little things could go wrong or big things. How do we make sure that if any of that stuff happens, it actually results in something powering down and going to a safe, kind of stasis situation? And so when you talk about the future technologies that we're looking at installing or that we have recently installed, they have systems that are set up to default to a very safe place. Does that mean that it is absolutely impossible for something to go wrong? No, there's always possibilities for that. Things that could happen outside of the power plant itself, and we see this with tsunamis, with earthquakes and other things, but we have designed systems so that the default is when in doubt go to a safe place, where the consequences of any type of accidents are minimized.

Ariana Brocious: So any kind of energy generation has risks and impacts, let's say, some of our fossil fuel sources like coal and gas have some pretty clear public health or environmental impacts from getting the materials outta the ground and burning them. So when we think about the risks that come from nuclear power, how should we think about the risks that come from low probability, but higher consequence.

Melissa Lott: Yeah, so exactly what you said, everything has trade-offs. So when we think about the consequences that could come from accidents, we can learn again from the past, from the very, very limited number of accidents that we've seen. I used to live in Japan, and so Fukushima is something that is certainly top of mind. Some of the risks and the fact that there were problems in that particular situation. You mentioned the water. I also have been following the research around the effects on topsoil and what it has done to communities. So when you look at the surrounding community and you look at impacts on top soil those bits of earth will not be safe for people to be around for hundreds of years, we may find technologies that could speed that up, but it's for an extended period of time. And so this is why we are so careful in our design of nuclear power plants, is because while we wanna keep the probabilities of any accidents of any type of power plant as low as possible, period, the potential consequences of nuclear are higher. And so within that, you know, hundreds of years to have soil be risky is not a small deal. And so we have to think that through as we go through the different risks. Now there are risks when it comes to coal-fire power plants. We've seen that with coal ash spills directly affecting health. We also see that with contributions to climate change and having really real direct health impacts on communities. And so what I'd say is just going back to the basics. When we think through the future of nuclear, nuclear is not gonna be something that every single community everywhere in the world wants to take into their energy mix. They may have alternatives. So I'm thinking about Iceland, where they have extensive geothermal and hydro resources that gives them firm power, that gives them firm renewable power. And so they use it to provide the electricity and the heat that they need for their communities to power their industries and that works. Other parts of the world don't have those types of resources. And so for those communities it's saying, well, given the options that are available to me, which ones am I gonna pick? And the key is to keep costs low and reliability high and to make it clean, you need three broad types of technologies. The first you wanna use variable renewables if they're available to you. 'cause they're very cheap when they're around. If they're not around all the time, so you compliment 'em with energy storage and then you compliment them with firm dispatchable power. And so that could be nuclear. Could be fossils with carbon capture. If you have poor space and you can put those greenhouse gas emissions, you know, under the earth or offset them some way, or in some communities it will be nuclear. And that is something that if you go over to France and you look at how they've decided to repower the nuclear fleet, or if you go into Poland, which is heavily dependent on coal for electricity today, they've decided to replace that coal with nuclear because of the security concerns. Because of the cost concerns, they've decided that that's the path they're gonna take as a country, at least for a good chunk of their electricity.

Ariana Brocious: There are a lot of concerns around radioactive waste and the US still doesn't really have a great system or plan in place for handling its own radioactive waste as far as I understand. So how do we deal with that, especially if we wanna build out more plants and in more places around the U.S.?

Melissa Lott: I think it's a really good, and it's an open discussion. Um, there have been plans that were put into place. I know Yucca Mountain was a lecture during my reactor design class 15 plus years ago. Um, oh goodness, I'm counting up the years now. Today the question is, okay, you know, at one point we thought we'd have one type of design for handling nuclear waste. The bottom line is we need a long-term plan for this, for long-term storage. So what is that gonna look like? Is it gonna be one centralized repository? Is it gonna be distributed in multiple places? Again, it comes back to trade-offs. There are cost trade-offs. There are risk trade-offs to either approach. So the question is based on the different stakeholders, including community members that are involved in the decisions. Which one are we gonna go down? Because we do need long-term solutions.

Ariana Brocious: Another main component of this discussion is cost and proponents of what's called, you know, advanced nuclear, some of these newer designs or, , or modules say that they could be cheaper, partly because they may be able to be built in different ways that are, that are cheaper than current technologies, but a lot of these newer technologies are largely untested at scale. So how do you think about this cost question?

Melissa Lott: I think about it in a few different ways. One is just the fact that we often focus on getting to net zero by mid-century or thereabouts. We also have to stay at net zero after that. So this isn't, we hit it and then we're good. It's no, then we have to maintain it. And so this is where a lot of different technologies come into play that you might not think about if you're only focused on the next, you know, let's say seven years to 2030. And so which technologies will be able to come on board and play a large role? The answer changes when you're thinking decades out and not just the next few years. So as we think through different nuclear technologies, What we might be able to do in terms of cost? A couple different things. One, we've learned a lot from cost overruns in the past and applying that knowledge to projects in the future is absolutely vital. Like we have to do that because it is an extremely tough situation to be in, where you know, you go to the store and you think that loaf of bread's gonna be 3 99 and you check out and it's gonna be 4 99 and then you get to your car and somebody says, oops, no, it's an extra dollar. You know, those types of things are really problematic. And the good news is we have learned a lot, so we can do better in that. But also when you come to these different designs and these different technologies, the ways we manufacture them, the ways we build the expertise we need to install them, those are things that can really work to our advantage when it comes to scaling up in terms of the number of reactors we can bring on the system. One thing I will say within all this, I also think about is what do we do with the existing nuclear fleet? 'Cause we can focus on new technologies all day long. But the reality is, in the United States, we already depend on nuclear to provide us with a lot of clean electricity. And if the goal is decarbonization and minimizing the impacts of climate change, those existing reactors are really important to keeping cumulative emissions down, which is what climate change really cares about. How much do we put into the air period, not just today, but over time.

Ariana Brocious: So I wanna get to fusion because this is really exciting, and there's some hope that this might be another future technology we can employ. So fusion is the kind of nuclear energy where atoms are fused together to release energy as opposed to traditional fission reactors where atoms are split. Fusion is what powers the sun, and it doesn't create radioactive waste that fission reactors create. The problem is that it takes a lot of energy upfront to get a fusion reaction going. Recently, scientists at the Lawrence Livermore National Lab achieved a net energy gain in a fusion reaction for the second time. So how significant is that development?

Melissa Lott: It's very significant in terms of a long-term future. It is something that, you know, when you talk about what the future of fusion could be, it makes timeframes of the next few decades more relevant to the conversation. What I'd say is, at a high level, it doesn't change what we're gonna do in the next 10 to 15 years, but it could really change the things we're doing around mid-century. And it's exciting. The technologies have so much potential when you look at the research and what is actually could be accomplished with them. This could potentially be a technology that helps us overcome some of this public opposition and concern and apprehension about nuclear and what it means into, in terms of our energy systems, in terms of waste, in terms of community impacts, like the list is long,

Ariana Brocious: Okay, so we're looking at this future. We've got a big demand for reducing our carbon emissions, a lot of energy and we already have existing nuclear. We're building out wind and solar. What's your proposal for moving ahead in terms of how much should we be putting our eggs in the nuclear basket? How much should we continue to build out renewables? Battery storage is coming along and getting increasingly more affordable, but, you know, what's the sort of balance that you see that would best prepare us for this next couple decades?

Melissa Lott: So when we look at the research and the analysis, I'll just zoom in on the United States just as an example. When I think about nuclear, I go into the work of many of our energy systems modelers. I'll quote Jesse Jenkins for today, which is talking about how much firm dispatchable power do we need in the future. He and his co-author Sepulveda, a few years ago, they said, you know, from all the evidence we're looking at, we probably need about as much as we have. Today, it'll operate differently. It might not run all the time like we have today's coal plants running, but capacity-wise, like the sheer number of megawatts we probably need about the same. And so I think in terms of putting eggs in baskets, there's only a few baskets you have to choose from when it comes to firm capacity when it comes to those technologies. And so we need to put eggs in all of those baskets because there are different reasons why in different geographies in the United States, the same is true in the world, while different ones will make sense.

Ariana Brocious: So in the US, only two nuclear plants have come online in recent decades, partly due to cost overruns and community opposition after accidents at Three Mile Island and Chernobyl. What do you see as the landscape now, the political and kind of cultural landscape in the US in terms of reception for nuclear power?

Melissa Lott: I think it varies a lot in the conversations I'm in, and one of the key differentiators that I've seen in these conversations, and this isn't universally true, but it is something that I've seen pretty strongly come through in conversations with different states, is, you know, states that are looking and saying, I have this really big coal-fired power plant as one example. It's not gonna be easy to retrofit it with some kind of carbon capture technology and you know, store that stuff underground. And so as a result, I'm looking at this really big coal fired power plant and I'm thinking, Could I actually develop that site, which has a cooling pond, has all these things, tons of wires coming into it and actually put a nuclear power plant there. Also in space constrained applications and military applications like nuclear is coming more into the conversation in a very practical way, how do we do this way, in other communities it's not.

Ariana Brocious: So to wrap up here, what are your biggest hopes and fears when it comes to new nuclear energy development?

Melissa Lott: So when it comes to new nuclear energy development, I have the same concerns and fears I have around any firm, dispatchable power, plant. A, that we're not gonna focus on it enough and we're not gonna build it out quickly enough, because if we don't do that, if we don't maintain the existing fleet, or as we retire it, replace it with new clean things, what ends up happening is a spike in the price of electricity. And that's not good for anyone. And I, you know, I think about the hundreds of millions of people around the world that don't have access to electricity, the billions that don't have access to enough electricity. In the United States, it's one in three people are currently energy insecure. Like these are tremendous numbers. And so as we transition, I. I worry that we won't spend enough time finding practical pathways forward for the technologies that communities choose in terms of the trade-offs, in order to make sure that they can go from an idea to reality to an operating producer of electricity. That's what I worry about.

Ariana Brocious: And what do you, what are you hopeful about?

Melissa Lott: I'm hopeful that we will lean in to understanding the needs that we have in terms of what gets us all the way to net zero. And I will say I'm very hopeful about it because I have seen in the past nearly 20 years of doing this, the conversation switch from How big of a deal is climate change? Okay, let's decarbonize by 50% or 80% to a, this is a big deal. It's affecting us already. This isn't just about future generations, it's already affecting us. We need to move as quickly as possible to net zero. And so when you talk about different pressures in the system, one of the big pressures in this system is social pressures. And we can talk about policy, we can talk about social movements, but overall, I think we're gonna figure out a path forward that protects us to make sure our electricity is affordable and reliable and also clean, moving forward.

Ariana Brocious: Melissa Lott is Senior Director of Research at the Center on Global Energy Policy at Columbia University. Melissa, thank you so much for joining us and sharing your thoughts on Climate One.

Melissa Lott: Ariana, it was great to chat. I hope folks enjoyed the conversation.

Ariana Brocious: Be sure to check out Melissa's excellent podcast, The Big Switch, on how to rebuild the energy systems all around us.

Greg Dalton: Today we're talking about The Nuclear Option on Climate One. Our podcasts typically contain extra content beyond what's heard on the radio. If you missed a previous episode, or want to hear more of Climate One's empowering conversations, subscribe to our podcast wherever you get your pods.

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Coming up, the argument that nuclear simply has to be part of our low-carbon future:

Jacopo Buongiorno: The magnitude of the challenge that we're facing decarbonization across all sectors of economies such that I think is not wise at this moment to exclude solutions that we know can work.

Greg Dalton: That's up next, when Climate One continues.

This is Climate One. I'm Greg Dalton.

Ariana Brocious: And I'm Ariana Brocious. I learned a ton in my discussion with Melissa Lott, and it still seems like there are a lot of complicated questions around nuclear energy.

Greg Dalton: There sure are. For me, one fascinating aspect of nuclear power is that it cuts across political divide – there are opponents and supporters of it among conservative and liberal groups.

Ariana Brocious: You talked with two experts on either side of this debate: Jacopo Buongiorno, TEPCO Professor of Nuclear Science and Engineering at MIT and Allison MacFarlane, Director of the School of Public Policy and Global Affairs at the University of British Columbia and Former Chair of the Nuclear Regulatory Commission.

Greg Dalton: I appreciated this conversation because it's nuanced and refreshingly reasonable, not ideological. We started by talking about the Vogtle plant – the nation's first new nuclear reactors built in decades, which just started up in Georgia. I've been watching this project for years and learned a lot from Jacopo and Allison about why it had so many problems.

Allison MacFarlane: The two reactors that are under construction in Georgia at the Vogtle site weren't the only ones that were under construction. There were two in South Carolina that were partially constructed and then abandoned after about $7 billion was spent. So it's clearly been a bit of a rough road. These plants in Georgia were expected to start in 2016, 2017. They were expected to start for a price of $14 million for two of them, and now the price is over $33 billion and only one of them has started so far.

Greg Dalton: Right. Tell us a little bit about what was designed; was it able to be built because there is often a debate about whether it's regulation, you know, the responsibility for these big cost overruns.

Allison MacFarlane: Right. Right. It's an excellent question, and something that bears much more scrutiny than it's already received. But Westinghouse made this design called the AP1000. It included a lot more passive safety features, quite a robust design, good design. And they started to build it in the 2000s. They ran into trouble. They built it under first of a new regulatory regime where they licensed the design of the plant and then were required to build exactly what they had said in their design certification. And they started veering away from that design certification which caused initial hiccups. And they had to go back and fix that. That was one problem. But the larger problem was that the plant was designed in modules so it would be put together like Legos. And the modules would be plugged into each other. And those modules it turns out were not built properly at the plant in Lake Charles, Louisiana. That plant had three different owners, the last one being Westinghouse. None of the owners could get it right. So when the modules were shipped to the Georgia site, they had to be re-welded. And that led to cost overruns. And this went on for years. There were also other problems at the Lake Charles Louisiana plant that went on for years. Eventually, this led to the bankruptcy of Westinghouse. And they almost took their parent company Toshiba down as well.

Greg Dalton: Jacopo, what's your take on the Vogtle plant in Georgia and why it cost so much and was so late?

Jacopo Buongiorno: Yeah, by and large I agree with Allison's summary of what has happened at Vogtle. This and the other plant that Allison already mentioned the two units which was eventually canceled. We're the first new nuclear build projects in the US in over 20 years. In one word what has happened to those projects is the atrophy of the nuclear industry which in the United States is exceptionally proficient at running existing nuclear power plants but quite clearly at loss and they're out to build new ones. The situation is very different in other countries. If you look at South Korea, China, India, Russia they've been continuously building large nuclear power plants and they routinely delivered those plants on schedule and on budget more or less for what we can judge from the outside. In the US that was not the case. So by and large the issues that have been at Vogtle would have been self-inflicted wounds by the industry. The companies rushed to construction without a properly completed design, the detailed design that is really required to build the plant. That's in many ways different from the level of design detail that is required to get a license from the NRC. The companies obtained the latter but not the former before they started building it. And, you know, it doesn't take a lot of expertise in construction project management to understand that if you are starting to build something that you haven't fully designed, you're in for a bumpy ride.

Greg Dalton: Well, anyone who's remodel a bathroom or a house knows that change orders are costly and expensive, when you start changing something once the hammers are already swinging. Allison, your response there that it's largely self-inflicted wounds by industry.

Allison MacFarlane: I think Jacopo is correct, it is atrophy of the industry. But I don't think it's unique to the United States. Certainly, France and Finland and the UK have been having a lot of trouble building reactors that they're building. Very similar story to the US. I wouldn't necessarily hold up India and Russia as icons of how to do it right. I don't think either of them are doing it right necessarily or well. We don't really have a lot of information about Russia and what they're doing. China has been working along and building reactors apace. South Korea built the reactors in the United Arab Emirates, but they are not without their problems. And the South Korean reactors themselves have been plagued by problems of falsification of records, problems with different materials that were substituted in instead of the ones that were supposed to be there. So there are a lot of issues there. None of these countries is a country that I would hold up in saying this is how we should be doing it.

Greg Dalton: Jacopo, with increasing deployment of wind and solar and increasing deployment of grid scale battery storage of wind and solar power, do we still need to add new nuclear to the United States electricity mix?

Jacopo Buongiorno: I think the short answer is yes. At MIT and many other institutions there have been very robust modeling efforts of the electric grid for individual regions in the United States or even for countries overseas or regions of China, etc. And almost no matter what assumptions you make within reason the models show that the generation mix that leads you to deep decarbonization of the power sector at the least cost and with the highest invariably includes a robust component of nuclear. And that is because if you try to achieve deep decarbonization and I emphasize the word "deep" here, not 10, 20% reduction in CO2 emissions but, say, 80, 90% reductions. If you don't have something that looks like nuclear which is low carbon and dispatchable or any way always on then you end up having to overbuild dramatically the capacity of solar and wind storage. And the aggregate cost of that overcapacity is massive even though on a levelized cost of electricity basis sort of one-to-one comparison a new nuclear power plant is certainly more expensive than say a new solar plant or wind.

Greg Dalton: Today around 20% of US electricity comes from nuclear. So existing nuclear plants are not enough. We need new ones.

Jacopo Buongiorno: Correct, Greg. And 20% is the share of electricity that currently comes from nuclear. But if you look at the share of carbon free electricity that comes from nuclear in the United States is roughly 50%. The same is in Europe of course you have other countries where the share is even higher. But the worst thing you can do to this fight against climate change and sort of the quest for decarbonization is to actually shut down existing plants. We’ve seen that over and over again up here in New England elsewhere in the United States. When you shut down an existing nuclear power plant, emissions will go up. That’s a mathematical certainty.

Greg Dalton: Right. And a lot of people on the left don’t like to hear that but that is a fact. Allison, your take on do we need new nuclear in this country to achieve deep decarbonization.

Allison MacFarlane: Ideally, probably, but I don't think it's possible. So I'm agreeing with Jacopo that we should not be shutting down existing nuclear, because it does provide carbon free electricity. Now in terms of new nuclear I just think that it's a really heavy lift. As Jacopo has pointed out the nuclear industry has atrophied in the US and certainly in terms of construction of new plants. And I don't see new plants being made in any kind of scale that would necessarily replace what we have operating right now in any reasonable time frame. And so I think maybe 20 years 30 years down the road nuclear could start to be built in enough numbers that it would attempt to address climate change. But we need to build things now that can be built within a few years and nuclear is not that.

Greg Dalton: Jacopo, your response. And some people would say that nuclear can't really make it in the marketplace these days it has to have some risk subsidies in terms of the Price-Anderson, you know, sort of a shielding liability for insurers, etc. there's a price subsidy there where new nuclear has been built as markets where the ratepayers prepay for the power before they start to receive it.

Jacopo Buongiorno: I would say that's probably true. I agree it's a heavy lift. The economic parameters certainly don't naturally favor nuclear in the United States at the moment. However, I will point out that we do have several projects that are starting now and there is a reasonable chance that these plants will be online before the end of the decade. The key question is how you scale up and I think that's what Allison was alluding to. I'm not sure that US industry is ready, they're certainly trying to get ready, but we'll see how it evolves. It’s important to understand though that at the moment worldwide only 25% of the emissions come from electricity generation. Now we can try to electrify other sectors and I think that's a real possibility, but not entirely. In some sectors just electrification doesn't make sense. So my point here is that we need a lot of energy, not just electricity energy in the form of heat energy in the form of hydrogen or some synthetic fuels if we’re trying to decarbonize the transportation sector. And nuclear is one technology that can play a role across these different sectors. I’ll mention one project that is likely to occur. My hope is within the end of the decade is between Dow Chemical and X-energy that's gonna be the first example in the United States of a set of nuclear reactors that will power a chemical plant that will provide heat and electricity not only to the grid, but also to a co-located col-sited chemical plant. That’s kind of exciting because it would be a massive potential market there.

Greg Dalton: Well, Jacopo, we already know how to build solar and wind and batteries to store their energy when the wind isn't blowing and the sun isn't shining. given the need for speed that Allison mentioned. Why should we just focus on implementing what we know works rather than chase some shiny new technology that may or may not be commercial and viable?

Jacopo Buongiorno: If you're trying to decarbonize, solar wind and storage will not do it will just not do it. Certainly, will not do it at the least cost, one. Number two, the magnitude of the challenge that we’re facing decarbonization across all sectors of the economy such that I think is not wise at this moment to exclude solutions that we know can work. The issues related to construction or regulations are real issues but they’re not unsolvable.

Greg Dalton: Allison, one of the promises of small modular nuclear reactors that they achieve manufacturing economies of scale, repetition, that are not custom-built each one. What’s your take on that manufacturing promise of small modular reactors?

Allison MacFarlane: Yeah, I don't know that they are going to meet the promise that they've been set out to address, which is there are many claims about small modular reactors that they are going to be cheaper because they're smaller. But the conventional wisdom for many, many decades around nuclear reactors was that the only ones we have that operate now around the world are large ones. And the reason for that was an economy of scale that you don't get with small ones. And so small modular reactors may be small compared to the large ones but they are not necessarily small enough for mass production. And that's sort of what's promised. And because the plants in Georgia were built at a factory and the appeal from many small modular reactor designers is factory production it’s not clear to me that based on the Georgia experience that factory production is going to produce reactors that will operate economically.

Greg Dalton: Well, the country’s largest public power provider, Tennessee Valley Authority is planning to build and standardize small modular reactors. Are you saying that that's not a wise path?

Allison MacFarlane: We'll see. That's what I'm saying. A lot of people make a lot of claims about what will happen and they put time limits on them. I don't think these timelines are reasonable. I don't think there's going to be some magic or miracle that's going to happen that's going to vastly improve the nuclear industry. And what we are really coming to here is a problem which plagues a lot of industries and especially a lot of these large productions, large build situations which is the first of a kind problem. And when you build the first one of a new kind of small modular reactor, say, it's probably going to take you a lot longer and cost a lot more, a lot a lot more than you had planned. Now when others look at that price tag and time to build even though you may say, oh well, we've worked out all the problems they are not going to want to buy that. They're not going to want to invest in that and that's the problem that plagues this industry.

Ariana Brocious: This is Climate One. Coming up, former regulator Allison MacFarlane responds to critiques that the Nuclear Regulatory Commission slows down the industry too much.

Allison MacFarlane: It's nuclear power, so you have to build things to nuclear quality. You don't want an accident. Accidents are messy. You need a regulator to make sure that you do things correctly.

Ariana Brocious: That’s up next, when Climate One continues.

Greg Dalton: This is Climate One. I’m Greg Dalton. Let’s get back to my conversation with experts on different sides of the nuclear energy debate. Before the break, former chair of the Nuclear Regulatory Commission Allison MacFarlane said that she doesn’t think small reactors will be significantly cheaper nor help accelerate the buildout of more nuclear power. Building smaller reactors in more communities also means more opportunities for public opposition. Jacopo Buongiornoo of MIT responded to her view.

Jacopo Buongiorno: The most efficient way to deploy small modular reactors is to do so in multiple units of the same site, preferably sites that already have large nuclear reactors. I think that's sort of the path of least resistance. The main value proposition that I see for the small modular reactors is not that the expected cost of electricity will be lower than large reactors. I think Allison and I agree with on that that it's likely it’s gonna be a little be higher. What I see as main advantage is that it reduces the overall financial risk associated with that first project. So if the magnitude of the investment is not 10, $15 billion, but 2 or $3 billion, for a lot of our utilities especially in the United States which don't have a very high capitalization, that's a much more manageable project, number one. Number two, if you're planning for multiple units of the same side you can start generating revenue from your first unit as you build number two or number three. All these factors should make the project a little bit more palatable. But the promise that the cost of nuclear electricity is gonna fall precipitously simply because we're going to SMRs I think that's not reasonable, and we shouldn't expect it. I also agree that the designs that are being contemplated now with the exception of the reactor components themselves don't lend themselves to high levels of modularity. Let's pick NuScale. They've done a very good job in modularizing the reactor itself. Everything is contained within a single vessel. And I'm pretty confident they can build those vessels and all the components inside within factories that'd be great. I think that might actually bring down the cost of that equipment. But the direct cost of that equipment is less than a quarter than the total cost of building the nuclear plant because they still need to build civil structures, you know, excavate the site, a lot of reinforced concrete shield building and all of that. That's where the cost is. So unless you can streamline and make it more efficient just modularizing the reactor components itself is not going to get you to the low cost that people are anticipating.

Greg Dalton: And Jacopo, I hear 1 or 2 billion is a lot more affordable than the 14 or so that we saw in Georgia. That's still a lot of money for venture investors, it's a lot of money for a new design for risk-averse investor-owned utilities. Is public dollars going to be required and could the Inflation Reduction Act which has some nuclear money help in that regard?

Jacopo Buongiorno: Very much so and as you probably know the Inflation Reduction Act does have a lot of money to incentivize the deployment of all low carbon energy technologies, including nuclear, solar and wind. This takes the form of production or investment tax credits. So as far as I know all the ongoing projects for new nuclear plant construction is planning to leverage those incentives without which it would be an even more difficult proposition.

Greg Dalton: Allison, one of the critiques in the United States is that the Nuclear Regulatory Commission has been slow, bureaucratic, perhaps too focused on safety over other things. used to chair the commission, what do you think of those criticisms and how is it approaching the nuclear industry today. It seems to be regulating an industry that's we all agreed is atrophying and yet it's also dependent on that industry for some of its fees.

Allison MacFarlane: Yes, it's a fee recoverable agency so it is dependent on the industry for the fees. But the larger point is that it is not the regulators fault that things are going slowly. It is difficult to design new reactors, new reactor designs. That takes a long time. Let me just take a step back and talk about engineering. Whether you're making a bridge, a building or a nuclear plant you design something on paper. You build a scale model. When you build the scale model you realize you had things some things wrong on paper you fix that. Then you have to scale up to full scale. When you go to full-scale you realize you had some assumptions wrong with your scale model. Where we are with most of these nuclear plants is the paper. The regulator is not part of this. Building your scale model is expensive. That's gonna cost billions. And then when you get to your full scale that's going to cost more billions. The regulator is a very small part of this. Now clearly, it's nuclear power. So you have to build things to nuclear quality. You don't want an accident. Accidents are messy. They are economically costly. Look at the Fukushima accident. I'm not talking about people being hurt or dying or anything like that. I'm just talking about the economics of it. And accidents affect the rest of the industry. So you don't want an accident. You need a regulator to make sure that you don't have accidents that you do things correctly.The general accounting office did a study some years ago now looking at this question of how much the regulatory costs are in the overall cost of developing reactors. And they found that they were less than 10%. So this is not an issue of the regulator. The Nuclear Regulatory Commission has been very forward-looking. They've been working very closely with a lot of designers on their reactors. And that's exactly what they should be doing.

Greg Dalton: Jacopo, how has Russia's invasion of Ukraine and their military attack on the Zaporizhzhia nuclear power plant in Ukraine changed how you think about the geopolitical risk of building more nuclear plants. These things are big targets and big scary targets during war.

Jacopo Buongiorno: The invasion of Ukraine by Russia has changed I think the picture for energy in general and for nuclear particularly in many ways. I'm gonna address the particular angle that you're asking about in a minute. But first let me say that a positive reaction that has come up, particularly in Europe is this sort of epiphany that Europe and countries in general cannot be at the mercy when it comes to energy security of other countries, especially if those countries are not allies. And this has put wind in the sail low carbon energy technologies, particularly in Europe following February 2022, including nuclear. The other aspect that you bring up is a very important one. And that is the security of nuclear power plants. So the situation at Zaporizhzhia has been critical for over a year. The site has been taken over by Russian forces. The nuclear operators, Ukraine nuclear operators have been abused many have been forced out many have chosen to leave. And so certainly not an ideal situation for the site at all. good news is that like old nuclear reactors, even these ones that were built by the Soviet Union had been retrofitted in the past decades with safety systems and they've been operated at standards that are consistent with Western safety standards. So there are very robust facilities. Now if you are determined, you meaning a terrorist or a Russian in this case a Russian army, if you are determined to create an accident and create some kind of release of radioactivity you can do that because there is a lot of radioactive material at that site. But the question we should ask ourselves is what are gonna be the consequences of such a release. And at this time at Zaporizhzhia, the reactors are being shut down for well over a year and the amount of radioactivity the amount of residual heat that has to be remove are such that by our judgment or judgment of folks that have been studying this now for several months the consequences biological consequences of an event that Zaporizhzhia would be minimal.

Allison MacFarlane: I'd disagree very much with Jacopo. I think if there's an accident at Zaporizhzhia it's very possible that there's a massive release of radiation. I don't think you can say it would only be a minor release. I think it depends on the accident. And we have to remember that at Zaporizhzhia they haven't been getting the maintenance and the materials needed to operate the reactor safely. And as Jacopo pointed out, the operators who are so essential to the safe operation of reactors have been really, really decimated there. And so it's a really dangerous situation. That's why the International Atomic Energy Agency and the director general has been paying so much attention and traveling there frequently because he's very concerned about the safety of that reactor. And I think the situation in Ukraine has given a lot of people pause about nuclear. Because if something goes wrong, it can be really bad. You know the Chernobyl accident it affected countries 2000 km away.

Greg Dalton: Your response, Jacopo.

Jacopo Buongiorno: First of all, I think the analogy with Chernobyl is completely inaccurate. The only thing that they have in common is that they're both plants in Ukraine. Other than that, different designs, different operating conditions, different safety culture and all of that. But the key about Zaporizhzhia at this point is that the amount of material at risk, which means the amount of radioactivity that you have there is so minuscule. And the number of barriers that protect the material are so massive and redundant that even without full staffing of those plants the chances of having a major release are really, really small. I think it's appropriate for the IEA to shine a spotlight and draw attention to the situation there. Nobody wants an accident whether it's small or large. This will have certainly an effect for no other reason in sort of a public perception of nuclear. But if we're looking at public health consequences of an accident in Zaporizhzhia frankly, I don't think it's something that keeps me up at night. broader question of security at nuclear power plants of course, is important. All existing nuclear power plants in places like China, US, and frankly, almost everywhere look a little bit like maximum-security prison. Very difficult to come in, their engineering built to be extremely robust. So I think you know they are among the most solid and impenetrable infrastructures that we have as society.

Greg Dalton: One big reason for the opposition has been to do with nuclear waste. In the US nuclear waste had been stored in temporary facilities. I believe Allison that's maybe how you got into this field as a geologist because no one wants radioactive waste stored in their backyard. What waste solutions do you see, Allison?

Allison MacFarlane: For high-level waste the solution is a geologic repository of some sort. We in the US have had a lot of problems just getting to agreement on this. There was a Nuclear Waste Policy Act that was passed in 1982 over 40 years ago now, and we still don't have a repository for high-level nuclear waste in the US. And the problem is not a technical one. It's largely a political and societal one. but we should not be building these reactors unless we have a plan for the most toxic materials associated with them and we don't have that yet. And we need to really get to work on that in the United States.

Greg Dalton: Jacopo, do you see climate change as an emergency. And if you do, do we have time to wait for new nuclear power to come online and address it? And I understand you said earlier that we need to decarbonize other sectors but staying on electricity do we have time for nuclear?

Jacopo Buongiorno: I think we do again I relentlessly go back to US centric or maybe West centric versus rest of the world. It’s not like we’re waiting for nuclear, nuclear is happening. Internationally there are 50+ reactors under construction by and large in Asia or the Middle East. more to come in Europe. Hopefully in the US as well. So it's already a big component of our clean energy infrastructure, it will grow even more. The question of scaling the levels that are required to address climate change is a very good one. But let me be perfectly honest. It’s not just nuclear. We’re going to have serious issues in terms of availability of critical materials and even construction materials if we need to decarbonize using solely solar wind and storage. There is no silver bullet here, folks. The magnitude of the problem is so high that we need to push on all the technologies that we know work. And if you look at the past, countries that have decarbonized, you know, to stay with your example the power grid most efficiently they’ve done it with the combination of nuclear and hydro. The countries that so far try to do the only renewables approach Germany, Spain etc. they frankly don't have that much to show in terms of emissions reduction.

Greg Dalton: Well, thank you so much for sharing your insights today on Climate One. Allison MacFarlane is Director of the School of Public Policy and Global Affairs at the University of British Columbia and a former chair of the US Nuclear Regulatory Commission. And Jacopo Buongiorno is TEPCO Professor of Nuclear Science and Engineering at MIT. Thank you both for sharing your insights.

Jacopo Buongiorno: Thanks for having me.

Greg Dalton: On this Climate One... We’ve been talking about the Nuclear Option in terms of decarbonizing our world, addressing climate disruption and powering our net-zero future.

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Brad Marshland is our senior producer; Our managing director is Jenny Park. Ariana Brocious is co-host, editor and producer. Austin Colón is producer and editor. Megan Biscieglia is our production manager. Wency Shaida is our development manager, Ben Testani is our communications manager. Our theme music was composed by George Young. Gloria Duffy is CEO of The Commonwealth Club of California, the nonprofit and nonpartisan forum where our program originates. I'm Greg Dalton.