THE BROOKINGS INSTITUTION

FALK AUDITORIUM

LEVERAGING ARTIFICIAL INTELLIGENCE TO TACKLE CLIMATE CHANGE

Washington, D.C.

Monday, December 2, 2024

WELCOME AND INTRODUCTION:

BEN HARRIS
Bruce and Virginia MacLaury Chair, Vice President and Director, Economic Studies, The Brookings Institution

KEYNOTE FIRESIDE CHAT:

TODDI STEELMAN
Vice President and Vice Provost for Climate and Sustainability, Duke University

MODERATOR: BEN HARRIS
Bruce and Virginia MacLaury Chair, Vice President and Director, Economic Studies, The Brookings Institution

PANEL ONE:

MARK FLORIAN
Managing Director, Head of BlackRock Global Infrastructure Funds, BlackRock

EMMA NICHOLSON
Senior Economic Advisor, Federal Energy Regulatory Commission

ZACHARY LISCOW
Professor of Law, Yale University

MOERATOR: BRIAN MURRAY
Director, Nicholas Institute for Energy, Environment & Sustainability, Duke University

PANEL TWO:

DAVID BROWN
Snow Family Business Professor, Duke University, Fuqua School of Business

HELENA FU
Director, Office of Critical and Emerging Technologies, U.S. Department of Energy

HIMANSHU GUPTA
CEO and Co-founder, ClimateAi

MOERATOR: SANJAY PATNAIK
Bernard L. Schwartz Chair in Economic Policy Development, Senior Fellow, and Director, Center on Regulation and Markets, The Brookings Institution

CLOSING REMARKS:

RONNIE CHATTERJI
Mark Burgess & Lisa Benson-Burgess Distinguished Professor, Fuqua School of Business, Duke University

* * * * *

20241202_Falk_LeveragingArtificialIntelligenceToTackleClimateChange_Webcast.mp3

HARRIS: Good afternoon, everyone. Welcome to this important event on AI and climate change. My name is Ben Harris. I'm Director of the Economic Studies Program here at the Brookings Institution. So I'm so pleased that you've all chosen to join us for this event, both in person and to a thousand RSVPs online. The topic we're here to discuss is both important and timely. Recent years have brought rapid advances in AI technologies, expand the capabilities of AI systems to applications in a wide array of new fields. At the same time, the impact of climate change, in particular in the form of extreme weather events, remains one of our most pressing global problems. As these two trends develop in parallel, a range of new opportunities and challenges related to AI and climate change are starting to emerge. On the one hand, I could help mitigate the climate crisis, helping researchers find cheaper alternatives to decarbonize our economy and eight assessment of exposure to climate risks.

On the other hand, the increased demand for energy due to air data centers is hindering efforts to decarbonize our energy systems. Today's event, jointly organized by Duke University and the Economics Studies Program at Brookings, will address these important topics. It is my special pleasure to welcome Dr. Toddi Steelman, Vice President and Vice Provost for Climate and Sustainability at Duke University, who will join me for a keynote fireside chat in a few minutes. Subsequently, we'll hear from six distinguished experts during two panel discussions moderated by Brian Murray, director of the Nicholas Institute for Energy, Environmental Sustainability at Duke University, and Sanjay Patnaik, director of the Center on Regulation of Markets here at Brookings. The speakers on the first panel on how we can manage the energy demands of air. Mark Florian, Managing Director, Head of BlackRock Global Infrastructure Funds and the Nicholson Senior Economic Advisor at the Federal Energy Regulatory Commission.

And Zach Liscow, Professor of Law at Yale University. For the sake of transparency, I'd like to share that BlackRock provides generous support to the Economics Studies program at Brookings, which helps make the work we do possible. I'd also like to reiterate Brookings' commitment to independence and underscore that the views expressed today are solely those of the speakers.

The speakers on the second panel on How can I be used to solve climate change are David Brown, who is the Snow family business professor at Duke University, Helena Fu, Director of the Office of Critical and Emerging Technologies with the U.S. Department of Energy, and Himanshu Gupta, CEO and Co-founder of Climate AI. The event will conclude with remarks by Rodney Chatterji, the Mark Burgess and Leach, the Benson Burgess, distinguished Professor of Business and Public Policy at Duke University and recently appointed Chief Economist at the company OpenAI. I very much. Or maybe the NGO? I don't know. Yeah. Thank you so very much. Look forward to the discussion today. And I'd like to welcome Toddi to the stage. Thank you.

STEELMAN: Thank you.

HARRIS: So welcome.

STEELMAN: Thank you.

HARRIS: So we have about 20 minutes. This is okay. Okay. So we're just going to just have a discussion. You're an expert on this. I am not. So maybe you could just start with sort of a broad assessment of the, your outlook for the impact, potential impact of AI and climate change and how you see things right now.

STEELMAN: Yeah, sure. So I think we think about the collision of three broad trends that are happening in this space right now. The AI revolution, the need to decarbonize the economy, and our desire to address climate change. And so if we start there, we need to think about and this is particularly what I think about as the role of the universities in that space. So, for instance, so at Duke, we're just a microcosm of what's happening in the broader, you know, society at large. So we need to increase our compute for the researchers that are on our campus, for instance, while we also adhere to what we call the Duke Climate Commitment. Two years ago, we made a commitment to focus the attention of the entire university on climate change.

And so it's a value proposition that we take very seriously. So then the question is, how do we meet the demands of compute for our research in our campus while also adhering to our desire to be carbon neutral as a campus? So that puts two values in tension. And the challenge for us at least, is that, you know, we need more GPUs. Those are the graphics processing units. Those go into data centers. We need to build data centers on our campus. When you think about the design of data centers, which many people are thinking about these days, you have to think about how much energy they take, how to cool them, where you're going to locate them, how you provide renewable energy for them. And so all of those things come together on our campus. So we get to think about all of those things as a microcosm of society at large.

HARRIS: And is this unique to Duke or other universities taking on similar initiatives?

STEELMAN: Other universities have commitments to the climate. I would say that they are similar to us in Duke University. We have a focus on education, research, operations, community engagement and external partnerships. So it's across our entire mission proposition. At other universities, I think we either see them leaning into the operations, how do they decarbonize their campus or the research proposition that they have. I think we're a little bit different n that we have a whole university approach that we're taking and trying to think about how you do that, copying comprehensively across a university.

HARRIS: So you're thinking about this from the perspective of university leadership? Yes. Do you think the professors or researchers will start thinking about this from…so, for example, in my house, I think about when I leave the lights on with my daughters who always leave the lights on. I think about my car when I drive, but I don't think about my carbon footprint when I do a Google search. So do researchers not need to start thinking about their own emissions footprint when they're conducting research?

STEELMAN: Well, I you know, that's a there are great things about AI and their challenges with AI, right? AI has the potential to really accelerate where and how we're doing research to improve our climate transition. But the energy that it takes to do that compute is intensive. I don't think individuals really, when we don't have really good tools for thinking about how much carbon goes into a particular run of a dataset. For instance, it's not a metric that we have developed. I mean, there's a rough you know, it costs ten times more energy to do an OpenAI search attribute search than it does a traditional Google search. Right? But when you think about running a large dataset, we don't have really good metrics for what that looks like.

That study is in it is very nascent in terms of how we do that analysis. And so when you think about what that looks like across an entire campus, we don't really have good tools to think about that. And I think in general, we don't have a good business model for even thinking about what that looks like at society at large. Like we don't know how to plow into the current costs, the externalities, whether that's carbon or biodiversity or water use that goes into a data center, into the price point on what it costs to do a search.

HARRIS: And so sticking with this theme around AI and research, how do you see AI transforming climate change research? Maybe both for how it's done and what the focus is.

STEELMAN: So when we think about climate research at large, the real power ends up coming from the enormous datasets that we can not only bring in, but then also combine. So if you think about what paleo-climatology, climatology can do. That's sort of the study of like hundreds of millions of years ago in terms of climate data. We can combine data sets that look at tree rain cores, corals, our oceans, tectonic plates and bring those all together to really understand what has happened in deep time, say, 500 million years ago. And when we better understand what has happened with those trends in the past, that can potentially help us predict what's happening in the future. So there's a lot we don't understand when it comes to basic climate science in these particular areas.

And if we can begin to understand the past better, we can understand the future. We see this happening in some of the more recent innovations in climate science. For instance, there's been a debate in the climate science community where we need to actually understand the underlying physics in our large models before we can actually make progress, to understand about what we can predict in the future.

But now we can use large datasets of weather to understand what's happened in the past, and then just use pattern recognition on what we can understand to happen in the future. And so those are two competing models of how we get insight. And there are academic communities that are sort of fighting that out right now. Like, can we rely on the old datasets? Do we have to rely on physics? What is that going to look like moving forward? But they both provide us insights. And so it's just interesting to see where that scholarship is headed.

HARRIS: Gotcha. And so maybe just sort of dig a bit deeper on your own research, which is related to wildfire management and governance. Do you see AI as an opportunity to help communities more effectively manage wildfire risk?

STEELMAN: I think we're seeing really interesting insights when it comes in three areas: remote sensing, the use of UAV, unmanned aerial vehicles or drones and sensor technology. And so we see all three of those collecting enormous amounts of data. And then the opportunity comes when we can harness that data to understand better where we think wildfires may happen, how to manage the wildfires when they happen, and then what does recovery look like? Post-fire. So in all three phases. So for instance, we have UVs that can help us understand hazardous fuels on the ground and where drought may be taking place as a precursor for where fires may happen during the fire. We can understand where smoke is taking place, where the boundaries of the fire are and how to plan evacuation better. And then post-fire the question becomes where are we going to see debris and what do the post fire boundaries start to look like? So it's an opportunity using AI, said the remote sensing the drones and basic sensor technology. We're also seeing the emergence of robotics. Think about sort of these robots that can go out and fight fire. And they take in also a lot of sensory data to help them operate better as well. So we're seeing really interesting cutting-edge frontiers in wildfire.

HARRIS: So I'm going to ask you an unfair question that requires speculation. But a lot of times when you mentioned AI, people immediately go straight towards the impact on the labor market. And with this, I think sort of fear that it will displace a fair amount of labor and you'll see a lot of job loss ten years from now. Will we still see the same level of employment with wildland firefighters?

STEELMAN: I think that we I think that wildfire in general is tending away to having so many firefighters on the front line. So the more we can do with robotics and the more that we will do in terms of putting non-humans in harm's way, the better. So I think we will see a trend in that direction. We're also having big trouble finding enough wildland fires to actually do that work on the front lines. So robotics presents a viable alternative in terms of not just safety, but in viability of labor force.

HARRIS: So fewer. Yeah, okay. But that's a good thing, right? We have a shortage of wildland firefighters right now. I mean, we've stepped out in the DC area, I think it was a year or two ago to all the smoke coming in from Canada, which was which was shocking, honestly, is I mean, it was like climate change and all the issues, like every breath you took. So it's maybe not necessarily bad news when the most dangerous professions you see employment decline.

STEELMAN: There's a lot of risk on the front line. And that's just what you get exposed to when you're in the middle of a fire. It doesn't count sort of the mental health and physical impacts post-fire that we are also seeing the wildland fire community face as well.

HARRIS: So moving forward with AI, there's a role for government. There's a role for universities and the research community. There's a role for the private sector. And I just might take that these roles are being defined or served working us out as we go. But given your role in leadership at Duke on this, what do you see over the next decade? So is the specific role with universities maybe taking up some of the benefits of AI that isn't as profitable and that the private sector won't take up?

STEELMAN: So it's a great question. The universities are not the private sector. We're not the public sector. We're not the philanthropic sector. We are the nonprofit sector, but we're not conventional nonprofit in the sense that our mission is really wide. So I think that suggests we have to lean into probably three aspects of our mission. One is convening how do we play a role much like this in terms of bringing together the right stakeholders in conversation so that we can make progress in key areas, that the private market will not address our research that we can do. And I think also in our education mission, I think it's really interesting to think about the kind of convening that we can do and where those sweet spots are, where we can bring people together that might not conventionally happen.

So you think about the larger societal questions that have to do with equity, with bias, Where are we going to actually capitalize on the ability to do energy generation transmission and basically the energy demand and supply? How can we do a better job of bringing that together in terms of where it's needed? So these traditional collective action problems that the market doesn't really solve for, how can we as a university in partnership with other of great think tanks, sort of have the convening so we can think about the larger societal issues that need to be addressed?

HARRIS: And so you mentioned education, which is interesting. And can you elaborate on that a bit? So who needs to be educated and what do they need to be educated about?

STEELMAN: Sure. So, I mean, at Duke, we think about this very broadly, which is we would like every student to you know, every major should be a climate major and every career should be a climate career. Like I defy you to find a profession where climate is not going to be affected. And then you layer on top of that the need to have literacy in a world where we're undergoing an AI revolution. So how do we think about these twin needs of climate and AI so that we can prepare the workforce, the future to be adequately prepared as we go out to deal with not only the challenges that climate change is going to present, but the revolution that AI is currently that is currently underway.

That also extends to, for instance, our alumni who are already out in the workforce. How do we create reskilling opportunities for them to come back to take advantage of these sort of twin opportunities and challenges so that they're also prepared to upskill in their current jobs? So I think there are a lot of challenges in the way you would think about climate, and I as an engineer is probably very different than the way you would think about it as someone who's in our divinity school, for instance. Yeah. So it's interesting to think about how you might grow up in a grassroots kind of way, what those skill sets are so that we can deliver well to our students both now and into the future.

HARRIS: Gotcha. So looking ahead. Can you let's maybe talk about, we'll end on a positive note, so maybe talking about challenges for AI, we'll get to opportunities in a second. But between AI and climate change, I mean, what are the if you're going to list the top 2 or 3 biggest challenges for the interaction between AI and climate, what would you say there?

STEELMAN: So I mean, AI is both a blessing and a curse. I think I and I think you mentioned this at the outset, right? AI has the potential to really help us find solutions both in basic climate science, how we begin to mitigate the challenges of climate, how we adapt to climate. So there's a lot that I can bring to the table in terms of increasing our knowledge, increasing our insight, increasing the wisdom that we have to deal with these incredibly challenging issues, just because the opportunity to amass large datasets help them balance insight into prediction and pattern recognition is huge. But we can't ignore in this kind of gets back to how do we ensure that we are playing the right role in society. There are lots of ethical issues associated with AI.

We don't want our robot overlords taking us over. So how do we think about equity and access and how do we think about making sure that areas that do not have access to the same areas and in sectors of our economy and in across the world have access to these tools in open ways? So I think there are a variety of dimensions in terms of where we have to think about not only what can I deliver and lean into the positive aspects of it, be clear eyed that we have to address the energy challenges that we are facing while also thinking about those who can potentially be left behind and the ethical aspects of being transparent, open and ensuring that we have good representation in our data sets and those algorithms.

HARRIS: And to try to size the energy challenges. So if you look at reports coming out of McKinsey and others, I think they're showing roughly 3% of the, today's grid goes towards processing of data and data centers. And by 2030, not that far off, it's gonna be more like six, seven, 8%. Does that feel like a reasonable size estimate to you?

STEELMAN: I think there is some pretty good confidence intervals around those bounds that, you know, smaller to larger. I think we know it's going to have a huge impact. What's interesting is that we've been through transitions before when we've seen large increases in compute and energy demands from data centers in the past. Those leveled off over time because we get more efficient in both our hardware and our software. But we are still on a very steep climb in terms of where we are right now with the increase in energy demand.

And I think that it's paying attention, I think, to those demand curves for energy right now. And then what can we do to build more efficient data centers, co-locate those data centers in ways where we can use the heat from those data centers, improve the hardware that goes into the data centers for greater efficiency, and also the software that we are that goes into the compute associated with the hardware as well. So there are many places where we can build on efficiencies at every stage in the process, and it's going to be really important that we're intentional, I think about that moving forward given the increases in energy demand we're going to face.

HARRIS: And do you think there's enough resources at universities being devote to these questions around efficiency or in the hardware and software?

STEELMAN: Well, you know, we have to build our own data centers. So we are working on these issues in real time. And the way we're wrestling with them, at least right now, is that we know that we have to deliver for our own researchers and do the same thing co-location, find renewable resources, figure out what the cooling is going to be, how are we going to reuse our water, what kind of renewable energy can we use? But we also know that we can't do it in isolation. We also have to have regional solutions. So, like Duke wants to work collaboratively with NC State and USC and L.A. and see Central in our region so that we're servicing a larger sector and not just thinking about these one-off solutions in each campus. So we have to really think more collaboratively about how we're going to do this so we can serve at scale and in ways that are more efficient.

HARRIS: Okay, so let's end on a positive note. I can play a major role as my understanding, in addressing concerns around climate change. If you're going to list the 2 or 3 biggest opportunities, the things that make you most hopeful here, what would they be?

STEELMAN: So I think we have huge opportunities on climate science, basic climate science and how we will improve the large integrated computer modeling models that we have for climate. I think that's going to get better over time. So we understand the Earth systems better. I think that when it comes to mitigation, we're going to see real gains in terms of how we use energy more efficiently across our entire energy systems.

So imagine utilities use AI to get smarter about how they are, how they switch between renewable energies and how they switch between conventional energy to manage their loads, balance their loads. And then I think also we can get a lot smarter when it comes to adaptation, especially when we think about models that help us, like agent modeling systems where we can put simulated humans together with natural data sets and understand what the consequences are for policy changes. So imagine we want to understand how carbon markets work more effectively. We can do that on much larger scales as well. So I think there's opportunity to understand how we can refine policy in sort of agent modeling systems.

HARRIS: I see. Okay. So your sales are generally optimistic. You've acknowledged some of the challenges, but overall, is your main takeaway that this is more of a blessing that occurs when it comes to climate change?

STEELMAN: I think that we have a real opportunity right now to get ahead of this, especially when it comes to the energy piece. And we're seeing a really interesting dialog not only nationally but internationally about how to engage in providing energy for these large data centers. And if we can get that right, there is a way for these hyperscalers, you know, the Microsofts, the Googles, the Alibaba's to really drive change in a highly productive way. They can create the demand for the next generation of renewable energy systems, whether that's nuclear or hydrogen or other, to get them over the hump, just like they did with wind and solar. If we're clever about it. So I'm a glass half full type of gal, so that's where I would leave it.

HARRIS: That's a great way to leave it. Everyone, please. Join me in thanking Dr. Stillman for this great conversation. Thank you. I think we'll welcome the next panel at this stage.

MURRAY: And I sit in the middle. I think things are fantastic. Hello, everyone. Do we have our friends on Zoom? That we do. Okay. You will see them shortly. I am Brian Murray. I'm the director of the Nicholas Institute for Energy, Environment and Sustainability at Duke. And I'm really pleased to moderate this panel on how to tackle the energy demands of air. We've heard a lot about the potential benefits of AI.

This is not the session to bring you down, but basically to make you realize sort of the scale and the scope of the challenge. Couldn't be a more timely topic. At the risk of getting myself a little bit back in the in the late 1980s, when I was looking into Ph.D. programs, I was being recruited by one university to work on the artificial intelligence of forest management. And I remember thinking at the time, boy, that sounds like a fad. So maybe I'll just kind of skip that. So don't ask me for any predictions on what's going to happen 40 years down the road, because my track record is not so great. But I mean, it's really come I mean, actually for a while it was sort of back and, you know, until it really AI really kind of reinvented itself to be what it is right now with machine learning and the advanced methods that it has. So. What I and datacenters have done is they've pushed us from this world, at least in the United States and really more globally.

But I'll start in the United States of a flat load growth world for the for the 21st century. The demand for electricity has been relatively flat after growing throughout the entire 20th century, and that was what we were all projecting. You know, the Energy Information Administration is all projecting now. It's just going to continue on flat load growth and then boom, data center start taking off, air starts taking off. There's data center power demands are expected to rise up to about 160% just this decade. The stat that was alluded to in the opening and in the US that would take us from about 3% to 9% of total demand and about not all of it is driven by air. Let's keep that in mind. There's a lot of reasons for bringing data together as one of them, but about a quarter to a third of that load growth is going to is attributable to air. So that's going to require billions in new investment, at least $50 billion in new investment just to meet air led growth.

And then that's going to put stresses on water and greenhouse gases. I the Nicholas Institute just released a report a couple of weeks ago for the climate meetings and our submission that looked at this from the U.S. perspective, what is what is the load growth looking like? So again, not just data centers, but also reshoring of manufacturing in the United States and electrification of households and transportation. What does that mean for the power sector, what the Generation X would look like, what the emissions will look like. And we've estimated that that without. So we looked at a couple of things. We looked at can we actually have renewable energy grow at the pace that it needs to grow in order to temper emissions, or are we going to be bound by permitting constraints?

And we found that at minimum there's likely to be a 25 to 30% increase in emissions above what would be business as usual in 2035 As a result of this new low growth. That'll still be lower emissions than we have today and a lot lower than in 2005, but not as low as we were on the trajectory to go. So that's something to keep in mind. I put a copy of the QR code for the report out on the front desk, and I welcome you to read that and get back in touch with me. So but we have a great panel to discuss these challenges. Before I introduce the panel and start with the questions, I'm told there are index cards that are that are or can be circulated throughout the room. So if you have any questions for the panel, please use those index cards and somebody from Brookings will bring them forward and I'll sort through them and try to ask some questions at the end.

So as was introduced earlier, our panelists, Mark Florian is the Managing Director, head of BlackRock Global Infrastructure Funds and Emmis Nicholson is a Senior Economic Advisor from Federal Energy Regulatory Commission, or FERC. And Zachary Liscow is Professor of Law at Yale Law School. So thank you, Mark and Zachary, for joining us remotely. So I'm just going to start with a general question to all of you, which is from your spec, perspective, what are some of the biggest challenges in expanding energy supply to meet the rising demands of air? And since you're sitting right next to me and I'll go with you and then we'll move on to the others.

NICHOLSON: Sure. Thank you very much. And I'm really looking forward to reading that report. I can say I've worked in the energy space for about 20 years and nothing has come on the scene faster than this new load growth from AI and data centers and computing loads. So it's certainly introduced, I think where there's already a challenge at the end, you just see this pacing and they called it the trilemma. If you are on the conference circuit, which is sustainable, affordable and reliable energy, and now we have this at this new, very quick, fast appearing load growth that I think we're still grappling with how to manage.

And I think one of the biggest challenges, just from my point of view and not one my agency has to face for the most part, I think is citing it is really hard to build things the United States, both transmission generation. So I think that we'd have to we'll have to do a lot of streamlining of permitting. And there's also that conflict with a strong desire, which is a very good one, to incorporate more stakeholders into siting and permitting processes. So I could I can imagine it'll be a difficult challenge to make, but I think siting is going to be challenging and then funding, funding the investments that are going to be required to meet these loads is also going to be a challenge. There are deep pockets in tech, so hopefully they'll everyone's expecting they'll pay their fair share.

MURRAY: But can you say a little bit more about the permitting challenges and kind of what lies behind them. We don't have too much time to go too deep in that.

NICHOLSON: But yeah, I will first. I forgot to add my call. I'm from FERC, but I only speak for myself and I'll speak for my agency by commissioner, more chairmen or commissioners or staff. So if I say anything that annoys you, don't worry about it, cause I don't have a vote. I'm not a commissioner who actually has. But we need to advise them on what to do. So I apologize. I should have said that first. But I think in terms of siting and permitting one note, as FERC does not cite any electric generation, so it actually would fall to the states. And we also only have backstop siting authority for transmission. A lot of the siting challenges are going to be faced at the state and local level. And it is I think, you know, there's that inherent tension of trying to bring community involved and consider things like environmental justice and other aspects that you would want to do to bring the community along and, in their development, while also this driving need to build things yesterday. It just takes an incredibly long time. I wish I had solutions. I do energy, wholesale electricity markets, so I'm going to leave that to greater minds to expedite that.

MURRAY: Maybe we can loop back a little bit later and talk about retooling, transmission planning and the order out in front of FERC right now. So, Mark Florian, what are some of the big challenges you see out there from your perspective in the investment community?

FLORIAN: Hi, Brian. Hi, everybody. Thanks for having me on the panel today. Just to give some context, we invest in power systems. We have for many, many years, both renewable and going way back conventional. And we also invest in data centers, in fiber systems as well as mobile telephone towers.

All integral to the future we're talking about obviously, is, as you've highlighted, Brian and Toddi and Ben talked about, there's a huge growth curve that 2 to 3 times the number of data centers, for example, in the US by 2030 that we have today. That alone in the US is about a half trillion dollars of expenditure to build all the data centers that would be necessary. And interestingly, it's not all AI. There's still a lot of growth in cloud computing and the need for cloud. We're just voracious demand of data and the amount of data we consume as a global society is expected to double by 2030. So that alone is driving it, and that's cloud. Plus, the AI is a new driver, so that all needs a lot more power. And there's a couple of challenges with that. And Emme named it a few of these, which I think are really key.

First is how do you find the land? How do you get permits on a local and federal basis to execute on and building power plants? How do you get grid connectivity or connectivity to the data center campuses that need to be built on top of just the logistics typically takes? I have a slightly different number, but 3 to 7 years to plan to execute on building a new power plant of scale. So on top of that, a lot of the major hyperscalers, the big users of data centers, Microsoft, Amazon, Google and there they make clean energy pledges, which are terrific. And that's the way it should be. But the challenge with that is that most clean energy as we see it today, is intermittent in nature. Wind and solar work when the sun is shining and the wind is blowing, but it doesn't. Otherwise, we can work on energy storage systems to try to smooth out that intermittency. But data centers need energy 24 seven every second of every day.

And actually the amount of consumption inside a data center can be really volatile, but it needs 100% of the capacity every second of every day. Otherwise, Internet won't work as we all want it to. So I see that as a big challenge is the intermittency of a lot of what we have in terms of clean energy supply today when we have a use case that needs energy every second of every day. And then the other thing I would just mention, which we're already seeing in different parts of the world, is this increase in demand for energy and the perception or the concern that it may squeeze out other parts of populist that uses energy and might increase pricing of energy or create potential shortages of energy in different parts of the world.

And we've already seen in Dublin, as well as in Singapore, that governmental entities are starting to put caps on the amount of new datacenters that can be built because of the concern of access to power. So a lot of things in terms of getting it all built, financing it, as I mentioned, the need for clean energy, but it's intermittent and then ultimately public policy issues that will be based in the jurisdictions where a lot of data centers are concentrated. All those are big challenges. I look forward to talking about some solutions. I'll stop there.

MURRAY: So, Mark, you know, a lot of people do think of the Hyperscalers as sort of almost coming to the rescue and that they have a sort of a willingness to pay above market price, I think, for the power in order to meet their commitments. What's your sense for how long that ride can last?

FLORIAN: I think it's really core to some of the companies I mentioned to drive the growth in datacenter capacity and capacity for AI specifically. And so we see a great willingness. We're in contact in talking to all these players, and there's a great, great willingness to put hundreds of billions of dollars in commitments behind building this data center. I think the commitments are there. It is a relatively concentrated number of companies that are willing to put their capital at risk to build out this capacity. But I think it very much is there just given the growth in these markets and how these companies are trying to satisfy that growth.

MURRAY: Thanks, Mark. Zachary, to you. Give us some of your thoughts on sort of the big challenges associated with meeting the demand needs.

LISCOW: Yeah. Thanks so much for the invitation to be here today and sorry to not be able to be there in person. So I think echoing others is that I think the biggest challenge is increasing our supply of electricity and water that's as inexpensive and as environmentally friendly as possible, especially given our concerns about climate change. But to do that, unless there's some major breakthrough that I wouldn't count on, we're going to need to buy a lot of renewable energy to use renewable energy. We have to do two things. We need to generate it. We need to transmit it often across long distances. So let me take those one by one. So first, to generate it, I think that there two big challenges within generation.

First, I need to deal with the siting issues that are, if anything, becoming harder over time. Localities are increasingly banning the placement of renewables in their jurisdictions. We talk about solutions, but I think New York and Massachusetts are leading the way here. It's moving its states to preempt state and local governments from local governments from banning these things. We also really do not want the IRA to be repealed since those subsidies are important for the generation of renewables. So that's the first thing we need to generate renewables like electricity. We need to transmit it. And I think that when a lot of people have in mind with transmission is a short distance transmission, but often what we need is transmission across many states because renewable energy is often really far from population centers.

And for that we need a high capacity, long distance transmission of the kind that we essentially have not built any of for a decade. So we need a major change here or else will eventually be unable to make the green transition that we need to provide electricity to the data centers, etc. So for this for transmission, I think there are three main challenges. First is sitting here that Congress needs to step in. FERC needs to basically preempt the government's transmission line. It's need to go across many states, very hard to coordinate a bunch of states and localities. So for me to step in and say that that's actually not enough major challenge are the incentives of local monopolist utilities who often do not want competition from out of state for cheap from cheap renewable energy.

So their incentives need to be changed are something that FERC in an expert here. But I believe FERC can do its part of that on its own. And then finally, we need issues. We need to deal with issues of national permitting. So this is a national environmental policy act. Once we actually are do began to be able to bill as long these long-distance transmission lines permitting the federal level is to hold them up for several years. We need to change that. And we can talk about how to deal with it. But in short, really it to transmit it. I think there are a host of policy issues that we can work on to improve things here dramatically.

MURRAY: So let's pull the permitting thread a little bit more, if that's okay. So what are some of the ideas that you have, Zachary, for how policy makers can help expedite the permitting process and that you said needs to be done? Authorities incentives need to be aligned. But can you dig just a little bit deeper and tell us what some of the specific examples would be of policy reform? And then I'll ask you to respond and then I'll get back to Mark on something else in a bit.

LISCOW: Yeah. So, you know, there are many different pieces of permitting. I think when people think permitting, they often think the National Environmental Policy Act. That's really with respect to electricity transmission generation, really, just actually just a piece of that, not even the majority of it. So let me talk about a couple different pieces. The first is this FERC preemption part. So right now, to build your line across a bunch of states and a bunch of cities, you might have to get like 50 different permits from each of the cities in each of the states. And you have to get all of them to build your, you know, your line from one place to another. And that's just like wildly impractical and say we're not going to build these things.

And in fact, this is a lot of why the about zero of them are these long-distance lines for a decade. So we need a national actor to step in. FERC is a is a natural one. Some also think that part of energy could possibly step in. But I think the most natural one and the one where the proposals in Congress to do so would be for FERC to have more than the backstop authority. And I mentioned before, rather be the not the entity that can permit it is there in this respect to permitting and actually transmission at the national level is the National Environmental Policy Act. So what happens here is for anything that goes over federal land or central funding or involving federal agency action, it needs to be an environmental review.

And that environmental review across all environmental impact statements today takes over four years and then often is litigated, often for a couple of years. Even when the lawsuit fails, it takes a couple of years. So, you know, you had to four years to fight for environmental review. Two years to litigate it. That's way, way, way too long. If you want to make the green transition, you know, anytime soon. So, all right, we can talk more about this specific things, but I know that there are some ideas that I talked about to speed things up from just basically capacity building, having more bodies to a permanent second set to the tougher side, which is having more involvement, but also by the public, but also being a little harder to sue.

MURRAY: Yeah, I think, you know, at the at the crux of this is I mean, people don't make permitting hard because they just like to make permitting hard. It's kind of harkens to a colleague of mine, Jim Salzman, and a colleague. He wrote a paper a couple of years ago in a law journal called The Greens Dilemma when the old Green when the new Green Deal meets the old green laws. And so these are all put in place for really good reasons for environmental and community protection. So, Emma, maybe talk us through that. Like, you know, like what are some of the challenges associated with like, how can you make permitting reform work while still honoring the environmental protections and the community protections that are intended to be there?

NICHOLSON: I wish I wish I could tell you I think it's a challenge that that certainly we're going to have to face as a nation. But it is certainly one thing is true is we're going to have to figure it out to meet these loads. And it is except depressingly in exceptionally difficult to build anything anywhere. Or Bananas, the acronym I'm sure we're all familiar with. I'm not a permitting expert. I don't do that in my day to day job. I would just note, just to the we mostly permit it's actually exclusively, 'scuse me, at FERC. Natural gas pipeline infrastructure interstate under the Natural Gas Act and the Electricity Act, the only permitting authority we have for transmission is in the event of that, the Department of Energy designates sort of a national interest corridor of transmission. And that's you can imagine how long it'll take to get to us. And then we've never, ever cited electricity transmission infrastructure at FERC. So it would certainly. Would something like that would take some time. And I, I would I can't offer any expertise on how to efficiently do that. But just to note that capable siting and legal people will have to have some challenges ahead to do that more efficiently.

MURRAY: All right. So permitting TBD, that is sort of clearly a key issue. Marc, back to you. BlackRock Global Infrastructure Fund's portfolio covers a lot of different areas. Are there any regions where the private sector has been particularly successful in managing energy costs for air applications? So kind of lessons can we learn from those examples?

FLORIAN: I do think it's, I mean, we've gotten to this point over the last 15 years. We've built a huge data center fleet, and it's generally worked pretty well. And it's been a matter of trying to find the capacity for power as well as the siting and everything else you need to make a data center work.

And Northern Virginia is a great example of that, where the state and local governments generally have had a favorable approach to data center siting and building. The local utility has been focused on creating growth in power availability and in clean power as well. And then you have the major players in data centers, users of data centers, as I mentioned earlier, Microsoft, Amazon, Google, NetApp and others that are willing to write long term commitments to support the construction. So you have all those things coming together. You could potentially have a lot of growth in Northern Virginia is the largest data center market in the world. Some estimate as much as 70% of all the Internet searches touch the Northern Virginia data center market, which is pretty extraordinary, if you think about it.

So I think there are examples of that around the world. I also think collaboration amongst the various key parties to execute on data center development and execution is really, really important. And give you one example, in Frankfurt, which is one of the key data center markets in Europe. There's a local utility that provides power. It's set up a subsidiary to focus on the development of data centers because it knew that this is going to be key for the region. And the beauty of that. And then they ultimately brought in private capital to help finance the growth of that data center development company that was a subsidiary of this power utility. Why does that make sense?

Well, the power, utility and expertise in procuring power and own land that own interconnection rights in a new how to permit projects in its local region. In the same time, they didn't have enough capital within the utility to develop this. And so private capital came in in a public private partnership of sorts to help drive the overall business plan. So if you can have collaboration by the key parties and by the way, some of the major hyperscalers I mentioned earlier are contracting, a lot of those data centers use companies contracting in Frankfurt for capacity in Europe. So I think you have collaboration around all the key parties here can really make things happen. As challenging as it is.

MURRAY: So, Mark, I'm going to get back to you and ask about the role that private equity can play in all this and maybe tease that out a little bit. You know, what role can they play in financing sustainable energy solutions in this space?

FLORIAN: Yeah, I mean, the public markets have continued to grow. But it's interesting because the private markets have grown faster overall. And there's a couple of examples of that. For example, commercial bank lending has grown, but there's been actually a much faster growth in private credit through private equity types of firms that are in some cases, just remediating the bank market and creating further capacity and growth. So I think you'll already see that there's huge amounts of investment from private equity infrastructure funds, private credit funds in the data center market and just in energy infrastructure overall, primarily power. And literally hundreds of billions of dollars has already been deployed between those sources of capital. And it will be an important source of capital, along with the public markets, to fund this huge need that we all have.

MURRAY: All right. Thanks. Zach, I'm going to go back to you and ask you about how should policymakers be thinking about balancing investments in new infrastructure to meet the energy demands versus upgrades to existing infrastructure? You know, a lot of the permitting, not all, but many of the permitting concerns we've talked about to date are lessened considerably if you're not building brand new greenfield infrastructure. So can you speak a little bit to that?

LISCOW: Yeah. So it would be great from a permitting perspective, from a siting perspective if we could, we use the sites that are already used, then you don't have to engage in a new battle about where to put stuff since there's already something there and there's a decent amount of bandwidth to do this, you can do something called re conductor ING or transmission to go from place to place be you put the old wire in place, the old wires, the new wires and you know, double capacity and, and like that's really great to be able to do that. But, but you know, but there are limits and it's important thing that you can do. But there are going to be a lot of live number one, really a lot more electricity and we're going to generate generator and that's generation going to require new siting.

Those sites are often going to be spas from northern Virginia where the where the data centers are. That's going to require, you know, transmission lines in places that, you know, are not where they currently are. So we need to build new transmission. So he's going to need to build new generation. We need to build new transmission. You know, we can try to keep the old nuclear plants going for a time, but ultimately just a lot more demands and there are limits.

So all in favor of, you know, we using what we have where it's cost effective. But ultimately, you know, when we come to health decisions, we're going to need to recognize that we have statutes on the books that are really old and that the world has changed quite a lot since they were written. And I'm talking here about the National Environmental Policy Act and talking here about that legislation authorizing FERC. Fact is we now have energy that needs to be generated really far from where it's consumed. It's really different from having the nuclear plants and the natural gas plants and the coal in the coal plants pretty close to where they're used. And then secondly, a climate change.

So you put the stuff that's really far away from where it needs to be used in climate change and. It means we often need a big rethinking of how we do things from a policy perspective and in particular, because often the thing that's more pro-environment now is building the not building because of climate change. All the more reason to rethink things on the ground. Thanks. So I'm going to as you point out, FERC really has fairly limited control on things like, you know, regulating where electricity is built and where it can be transmitted, but do have some regulatory authority over wholesale energy and ancillary services markets. So can you talk a little bit about, you know, how are those markets responding to the growing demand for energy brought on by air and other sources?

NICHOLSON: Sure. Sure. And that's correct. We can't direct the Federal Power Act, which is the enabling legislation statute that FERC works under. We can't direct generation or cite it, but we regulate a construct. You're probably familiar with the wholesale electricity market. We regulate six of the seven wholesale electricity markets in the United States. And they have all of them have energy market, energy and answering service markets. And all three of them have a capacity market and capacity market because we were talking about we need to build this stuff. That's a really important feature in how to fund gen generation, new generation capacity in markets that have them.

There's a map. If you go to FERC Web page, you can Google or just Google articles. You'll see like a map of the US and a couple of color blobs. Only part of the country where most of the load happens to be served by wholesale electricity markets that we regulate directly outside of those markets, their traditionally regulated system and data centers are appearing in both RCO and honored.

You know, there are two areas and there's within the whole the auto area, the wholesale electricity markets, capacity markets are designed to send investment signals to power plants to either build, retire or delay retirement based on a projection of load, a projected load need. They're typically either one year or three years forward. So that's one big signal that we're counting on to drive investment in new capacity. Again, as you've noted, we've had a pretty flat load growth load curve now. And now it's increased. The one in addition to I don't really want to depress everybody, but in addition to the challenges in siting and permitting new facilities, there's also a challenge in interconnecting them to the grid.

And there's a very exciting interconnection to issue which we can table that. There's another issue we have to resolve to quickly build stuff. So the capacity markets within the ISOs are a driver and also outside the ISO's, there's actually some really innovative deals that large data centers, very large tech, big tech are developing with their local utility to be included in their integrated planning process, which is how they build capacity to serve their loads like Southern Company and via Energy Duke and also the tech companies themselves, as I'm sure we're all aware, outside of the capacity construct and the working directly with utility are funding their own infrastructure. Like Smart and other TMI, Constellation is working with Microsoft to reopen and relicense on Three Mile Island, also the Palisades plant in Michigan. It's going to be reopened. So there's a lot of creative ways people are trying to work together, both within the capacity market, construct, the integrated planning we construct and direct purchase power agreements that are being used to fund some of this new infrastructure generation capacity. Excuse me. Yeah.

MURRAY: We have some great questions from the audience. I'm going to hit one of them right now, sort of a combination of two of the questions. So are free to use AI tools part of the problem, Right. So should we just be focusing on expanding supply to meet this seemingly endless demand, or should we be doing some things on the on the demand side? And as part of another question, have consumers ceded the energy decisions to the Hyperscalers? So there's no assigned respondent to this. But if anybody wants to jump in on this, please do so.

NICHOLSON: I can jump in. I think yes, I think it's horrifying that like I could just sort of like have them make a video of my dog or like a video about bananas or some kind of nonsense. Right. And then I have no bearing or consequences for my decision, not even like a visual of what I'm doing. So I'm and whenever I see those, like, fan graphs and projections of data center loads, I kind of hope and pray, well, that assumes like today's kind of limit, you know, resource free seemingly to the user and user use of. This one could only help if you price it more appropriately and we actually start hitting capacity constraints, it will be used more judiciously. And as our first professor said, when we can expect greater efficiencies in computing and the combination of both, you know, better computing, better algorithms, more efficient machines that are cooling, all of that could hopefully sort of tamper down the upper end of those load curves. But of course, then you have electrification and onshore and who knows what will end up. But I would hope that there would be something to moderate that because it seems a little bit unsustainable today.

MURRAY: Yeah, it's kind of interesting. I mean, Tony mentioned earlier that a search aided search takes ten times as much energy as a simple Google search. Is there such thing as a simple good Google search anymore? Because now and this is like the last few weeks, like every time I go to Google, two thirds of the time it comes back with an AI overview to the question that I'm asking it. So I've even lost my ability to say no, you know, maybe I don't want to go there. Google goes and does it. So that's sort of an interesting, interesting development there. Zachary or Mark, any thoughts on this?

LISCOW: Yeah. So, listen, I'm an economist, so, you know, economics, you know, doesn't have always have the right perspective, but it's a decent baseline often. And I think it is here some of the facts of economics, the kind of the way to do this is to have the price reflect the cost of production and the externalities to the world from global climate change and other impacts on the environment. And then, you know, the private sector and individuals will have their preferences and act accordingly. So currently we do not have the right price and low price because we do not have a carbon price and I do not think we will have one anytime soon.

So it's important to, you know, for our policy actors to do what they can in the absence of that, both to, you know, to kind of compensate for the fact that we don't have a carbon price and to remove the regulatory barriers that are, you know, making it harder to build clean energy, which have the effects of both, you know, those barriers both increase prices and increase greenhouse gas emissions. So that's a double whammy. So the way I look at this is basically the lever that we have is policy. We're not going to do a carbon price anytime soon. So what we can do is remove the barriers to clean energy. And those are the things I described before make permitting easier through revisions to the National Foreign Policy Act, giving FERC more authority to permit across many states and jurisdictions and change the incentives of utility companies so that they you know, that that that they want the cheap energy from out of state and not stuff They do not want that competition.

MURRAY: Mark, any thoughts on this?

FLORIAN: Yeah, I do. I do think it's a challenge. I think, you know, Zachary said it right, is that we don't we don't have pricing that reflects the amount of compute use and therefore the power use. And I think of, you know, our family, we have the friends and family plan with AT&T and we pay for unlimited volume of use of mobile. In Mobile, by the way, is the fastest growing and ultimately the biggest use of data. So it's that's a great example of where we're not really being asked to pay for our volumetric use of our and compute power. I do have a couple of other ideas, though. I think that hopefully will be solutions that we can lean into the future. One is just lowering the amount of electricity we need for compute.

And so ultimately, I think technology should be a solution here where we can have greater compute per unit of electricity or power consumption. And that, I think, has to be part of the solution here and how you execute. And I think the technology companies and videos of the world will be focused on this as part of their design feature, chips and chipsets. Also, there's a lot of work going on with regard to cooling in data centers is, you know, about 1.3 and 1.4 times the amount of electricity used for compute. And the data center is actually used for heating, ventilation, air conditioning and other ancillary uses. And so it really matters. And so there's a lot of work going on in and around more efficient cooling, which will reduce energy consumption. And then I think we need new sources of power.

And you've already referenced small scale modular reactors for nuclear could be a great source of one of the big players. Technology players are now starting to put some capital behind the development of new technologies such as assemblers. And government can play a big role in that too, in already is in terms of providing loans or other means of trying to develop those types of clean energy technologies faster. That's not coming probably till the 2030s. But nonetheless, we're going to need it. Given all the growth here, last thing that just strikes me in this whole conversation is the more compute power we have available, and particularly if we're not being asked to pay for every unit of compute power we're using, the more we're going to find ways to use it.

And I know a lot of you may. Have been in San Francisco or L.A. and seen memos running around driverless cars that are taxis. I've been in one. I think they're pretty cool. But the amount of compute power it takes just to have one driverless car constantly analyzing everything goes around it, as well as thinking about, you know, how it interacts in the overall vehicular system. It's just immense. So we're going to find more weight, more ways to consume compute. So we have to find ways to limit the amount of power use and have cleaner sources that are 24 seven available.

MURRAY: So a couple of things there. Just we haven't talked much and I don't suggest that we do a bit like in terms of quantum computing and how that could actually improve the efficiency of data centers in AI. But the cooling problem with quantum is even more severe than this with regular computing. So something to think about. But several people in the Q&A and in the audience did pick up on nuclear as an issue. One person says very small, extremely safe. Nuclear reactors have been used in nuclear submarines for 70 plus years. Why can't we do more of this? As many of you know, Microsoft just struck a deal with Constellation Energy to reopen the closed part of Three Mile Island nuclear plant, not the one closed in 79, the one that closed just a few years ago. And then small modular reactors, you know, this may be where the hyperscalers, quote unquote, come to the rescue as we started talking earlier about that. So do you want to start with the Uma and then the rest will take it and then we're pretty close to done after that.

NICHOLSON: I think that's certainly true. And that's one of a really a nice silver lining is the new I've been working in energy for over 20 years and some of us have been around the corner for the whole time. So we really great to see that hit the market and reopening some nukes that have recently retired. I've read I don't know for sure, but Nancy, the Nuclear Regulatory Commission, they they're probably going to need to staff up because there's an appeal that there's a human capital shortage, I think, in civilian nuclear energy in this country, that in order to support that growth that the big tech is funding, we'll probably have to rebuild that capacity just so we can operate it safely and safely operate it.

MURRAY: Anything else on nuclear? Zachary and Mark alluded to it a little bit earlier.

LISCOW: Yeah, I'll just say like I hope it works out really creative in the 2030s, if a bunch of smart is that can you know, if not all of you know they can provide all of our electricity. It's uncertain. Might work might not work you shouldn't count on it. We carried on it in like didn't build out the clean energy then we're gonna be stuck using fossil fuels into the 2030s. So I think we shouldn't count on it, you know, And, you know, opening up these. These nukes I happen to. I grew up five miles away from Palisades, Michigan, in rural Michigan. But it's kind of it's costing billions of dollars to restart that. Things like that. That's not a super economical solution, although it's I'm glad that we're doing it because that's the energy. And I think it's also provides some jobs and in part an area of the country. But I hope it works out, but it just shouldn't count on it. So I think there's other things not out of breath and sharp that we need to do all these things because maybe we'll have super clean smarts in several years, but I wouldn't count. What climate's too important.

MURRAY: Okay, Well, and then we'll talk about Fusion next year when we talk about Quantum. But it's we have about a minute left right now. So I was going to ask each of you if you could just give sort of a quick summary. Take home message is that you want to leave the audience with about, you know, key concerns or messages on this topic. So, you know.

NICHOLSON: It'll take a village I think it'll bring to this challenge, will bring multiple disciplines to bear. But I think I believe in American ingenuity. And me and the group the Greatest ever held us back from developing before. And we might have to make some changes, do some things we're uncomfortable with. But I think I think we're up to the challenge.

MURRAY: Optimistic message. Mark?

FLORIAN: Sorry. Yeah, no, I think it is a huge challenge. And the only way we can deal with the challenges find new ways to provide either energy efficiency or cleaner supply. And the existing systems are great. But to meet this challenge, I think we need something new. And so, like I was saying, we have to figure out ways to lower the consumption of either the rack around compute or the computer itself. And then we have to find newer sources of energy that is not carbon intensive. And right now, small scale new modular reactors seem to be it. But there are some challenges. These companies are relatively young, and some of them had stubbed their toe on the way to getting to commercial production. But I do think in the 2030 we're going to see the installation some of these and hopefully, like Zachary says, I hope it works and works well, we're going to need it.

MURRAY: Well, the mute music is coming on in the background. So, Zachary, real quick. Any key messages for the audience here?

LISCOW: Yeah. Two things. First, while I really hope that, you know, you should do as much as you can to increase efficiency, I think ultimately, reflecting what Mark said, I think we want an abundance mindset here. Like we need we need to reduce production, need to increase production of electricity, especially clean electricity, in a way that is not from the environment. Rather, improve the environment, reduces our greenhouse gas emission, not increases that. Second, because they know it's good for the good for the economy, good for the environment. Second, I think we respect the policy. We really need to rethink older orthodoxies when our environmental laws are passed. And circa 1970, the way to help the environment was to not stop building the highway, etc. Now we've inverted that. Now it's often the case that builds are intended to help the environment we need to build. So often the problem thing now is going to be the bill. Going to require a change in the laws, change the usual doctrine, and it's going to be a challenge for those of us who care a huge amount about the environment to get there.

MURRAY: So new pathways will require new thinking and new policies. I think that's the summary point right there. So if you all will, please join me in thanking our panel for a provocative session.

PATNAIK: All right, everyone, do we have our virtual participant online? So it's perfect. Hey, man. All right. I think after the panel of lots and lots and lots of challenges that we see, I'm going to try to end the workshop today with the opportunities panel with a positive message, because as we all know, AI has tremendous potential to improve our lives in many different ways. And I think climate is one of those and there's a lot of potential to really find new solutions for climate change with AI. And so we have three amazing panelists here today. We have Himanshu Gupta from Climate Air on the panel here virtually. We have David Brown from Duke University and Helena Fu from the DOJ. So I want to start off with a gentle question to all three of you. When you look at kind of like the perspective on AI and the intersection of AI and climate, what do you see some of the biggest challenges in our fight against climate change? Where I could really have a big impact. Why don't we start with you, Himanshu?

GUPTA: Thanks, Indra. It's good to be here. And apologies for missing out being there in person. I just came back from Japan, like a few hours ago. So as you talked about the challenges and opportunities, we think of it as a time and effectiveness multiplier for the solutions of climate change. So think about the light bulb on a top of your head right now. And., I don't know whether I can hear the audience or not, but can anyone guess What would light bulb have anything to do with the air and climate conversation we are having here?

PATNAIK: No. No takers.

GUPTA: All. So. You know, in the early 1900s when Edison and his squad members were working on commercializing light bulb, it took them almost a year and a half to four years to perfect. The filament of light. In fact, what they were trying to do is figure out a filament that can be filament material that can withstand temperatures of thousands of degrees for at least 9 or 10 months to be able to commercialize a light bulb. And so they took 10,000 of literally thousands of experiments with various material for this material until they zero down on bamboo filament Baghdad.

But imagine now with the simulation techniques that you have, it would have taken them basically minutes to figure out the same material. And back then, light bulb was considered a clean technology. Believe it or not, because it was an alternative to guys in labs or retailing beetles. So for us, that's an example of how can I can help accelerate the solutions of climate change and to the point the challenges are also linked to the solutions of climate change, where we are running out of time and money as well. In pharma there was close to in pharma, in pharmaceuticals, they invest 21% of their annual revenue into R&D. If you look at climate tech, the with one and a half, $1.3 billion of losses happening at the year, just in short and in short, combine the funding that goes into climate tech is still 30 to $40 billion, less than 2 or 3%. So how do we get more out of every dollar spent to find solutions? And that we are funding is a challenge. And that's also coming.

PATNAIK: Great. Wonderful. David, how about you? Where do you see the biggest potential for AA to have an impact?

BROWN: Yeah. So I think there's a lot of directions you could take this question. I think I if I were to point at one thing, I would point at climate modeling. In the longer term, you know, thinking about the challenges we have with the physics-based models, the spatial temporal resolution, they're computationally very, very demanding. And so I think with AI based models, you can circumvent a lot of that computational difficulty and think about local planning at the municipality level, neighborhood level, even, maybe even household level, thinking about adaptation and planning and resilience planning, I think I can be a really game changer for that. So that's kind of what I would think about. Again, lots of other kind of more detailed things we could talk about will unpack some of that in some of our questions here. But that's kind of what I would point to.

BROWN: Awesome. How about you, Helena?

FU: I mean, there's a, I think, a really exciting horizon on what is possible, right? Whether it's I for scientific discovery materials discovery, which will have so many different implications in the energy sector, climate weather modeling. I think AI on the grid is a is one where, you know, we're going to need to see some innovation.

Currently seeing a lot of AI on the sort of outside of the perimeter applications. But I think kind of looking forward, how do you get all these different disparate sources of energy onto the grid in a timely manner, in a way that is flexible and is able to kind of address intermittency and other kinds of challenges that currently exist?

PATNAIK: So let me stay on like your work at the DOJ. How does it fit in the greater mission of the DOJ? Yeah, it's not the first place we would think about AI applications, but I'm curious to see how you and your team and your colleagues see that. Yeah.

FU: And in fact, you're just reflecting on some of the earlier panels. We are investing a lot in AI already. Many of you may or may not know this, but do we as actually the steward of three of the fastest supercomputers in the world? In fact, as of two weeks ago, the top three at three of our national labs, two of which are open to the scientific community. I think what is not often known about you is that we steward scientific infrastructure for the country. So this is not just pure energy. This is, you know, the most powerful x rays, genomic centers, nanoscience centers. And, you know, this kind of infrastructure creates an enormous amount of data. Right. And I think we can all agree that large language models, general purpose models now are extremely useful for our everyday lives.

But I think what we are excited about and I think maybe some of my colleagues from academia are potentially excited about, is the application space in science and the application space and national security, which will use large language models but may also need physics informed models, models that understand chemistry, biology and math that don't speak just language. And so that's what we're very excited about. We also talked a little bit about permitting in the last panel. One thing that we have been investing in is actually AI for permitting. We have a project called Voltaic with an eye in the middle where in fact, we've taken the last two decades of NEPA data and tokenized and made it AI ready and available and released it to the community for. For academics and industry to build tools around. And so that's already out there in the world.

We think that there's a huge amount of opportunity space for both for permitting, but also to speed interconnection. So our grid deployment office just recently announced a funding solicitation for solution sets in that space because that's one of the big areas where there's a lot of energy pent up in the queue. So if we could speed up that process, that will get us that much closer to getting more energy onto the grid.

PATNAIK: That's so interesting. And I get back to the word take program a bit later. David, how about you? You've done a lot of research on the energy transition. How does your research look like at the intersection of identity transition? What do you find?

BROWN: Yeah, So thanks. So broadly, my research is about developing optimization algorithms for efficiently deploying resources in complex environments affected by uncertainty. And they're dynamically changing over time in so many applications. And of course, the energy sector has been sophisticated in embracing these tools for a long time. And some recent research. What we're trying to look at is really dynamic unit commitment planning. So thinking about tackling the debt curve and tackling energy intermittency of renewable resources. So they're really if you think about an integrated system, operators planning problem, like think about a Duke Energy or Dominion, like a key challenge, they're thinking about what is the system net load going to look like over the course of the next 12, 24 hours? Right.

And so you can think about this kind of in two steps. One, think about your predictive AI for predicting that system, that load over the course of the day and throw your fanciest, you know, neural network-based model, whatever forecasting model you want to use. Now, as good as those models are getting, and a lot of that is about predicting weather uncertainty, kind of now casting that in the short term, there's still going to be uncertainty and that you're going to really get a cloud of scenarios that come from that. Right? And so if you're a system operator in that cloud, by the way, it's going to get more and more diffuse as we think about more solar, more wind, more intermittent sources. What do you do as a system operator for planning there? Right. And so current practice now is fairly sophisticated. But one thing you could do is just take the average of that that big cloud, take the point forecast plan around the average. And what we're arguing this work is that's actually not the right way to do things.

The right way to do things is to think about what could happen in every kind of state of the world six, eight, ten hours down the road. And how do you want to be managing your hundreds, maybe thousands of resources smartly for all those different conditions? So kind of a full contingency plan. So that's what we're looking at in this in this work. I'm very excited about it. So kind of giving a benchmark of efficiency gains. You could think right now if you look at a system like a Duke Energy, for example, 2 to 3% lowering average costs while lowering risks, potentially double or maybe even triple that depending on how much solar and wind kind of increases over the next ten years. And these are models, by the way, that, you know, you don't have to melt supercomputers that you can actually run the laptop. So that's the kind of work I've been doing and I'm particularly excited about that.

PATNAIK: It's very exciting, actually. And these are significant cost savings. Yeah, that's amazing. Himanshu, turning to you, I mean, you your company is one of the few ones that are really in that space. What do you do with climate? How do you leverage AI to tackle challenges posed by climate change?

GUPTA: Absolutely. So I think I'll go back to my earlier framework of yeah, actually helping make, helping increase the effectiveness of climate solutions. And I had a big increase. I think at a time when people are accelerating some of the climate solutions over time and affect them as demonstrated by the two framework, this is one thing, but we look at and the effectiveness dimension is what we talked about, like including the reliability of renewable energy into the grid and hence increasing the grid operations overall. I'll talk about the time dimension. And so we work with 30% of the seed industry. By seed industry, I mean the crop seed industry globally. Their biggest challenge and currently the biggest challenge for farmers is to get their hands onto climate resilient seeds as fast as they can.

And one of the problems there is, is as these seed companies go on to launch these seeds, it takes them 10 to 12 years to launch these seeds. And by the time they launch seeds into the market, climate has already changed and those seeds are already ineffective. So one of the problems that we observed in the entire process of this seed development from all the way from research to commercializing to the market, is the time it takes to trial multiple seeds. So as an example, if a company wants to launch drought resistant cucumber seeds somewhere in India, then they would need to figure out locations where they can trial those drought resistant seed guarantees, either in India or somewhere on the nearby markets where they have just a. And the right result is already available. That the only process used to be based on me sending out things like obscure for people across multiple locations in India globally. And these people will literally be camping for 2 or 3 years collecting a lot of soil data, whether they have climate data, reporting it back to the headquarters and the and spending at least half $1 million, $2 million per part per campsite to be able to figure this out, what this ad is like, if we can identify in our case, what these companies do is they come to our platform and they say like, hey, I want to grow.

Could launch a drought resistant cucumber seeds for this specific region in India. They think you draw a circle on the map and the and the algorithm automatically extracts the soil, the water characteristics, the climate characteristics that led to high yields that will lead to higher use in that location and matches it to a location nearby or globally. So reducing the time to conduct these trials to basically from three years to minutes and cost from half $1 million to basically thousands of dollars. And that's and then as I mentioned, this platform is currently being used by 30% of the crop yield industry. So that's the other way of the time dimension I was talking about how do we activate the solutions of climate change, especially in this case for improving resilience of farmers?

PATNAIK: That's super interesting. I want to go back to Helena, and you went from a really interesting part of what God will take. And so you said you're developing this program at the area to help with permanent. Can you talk a bit more about this? Because I think we have done some work here at the center at Brookings that one chatted with. Permitting is oftentimes the capacity, right? Like the lack of capacity at the local level. At the state level, people don't have to staff people don't have to expertise. Is that where your program fits in? I'd love to hear more.

FU: Yeah. I would actually take one step back from that. I mean, we have a do we mobilize the entire department to make sure that we are addressing challenges related to this issue? Because remember, this is not just about rising data center energy needs.

This is about electrification of the grid. This is about manufacturing coming back to the United States. So we're going to need to deal with this situation, whether or not it's about data centers. However, that's the first part of the curve. And so I think, you know, across the department, whether it's looking at all of our loans, our tax incentives, our technical assistance that we can provide to localities to address the regionality of this issue, this is something that we're very, very focused on. So we've been convening many stakeholders from utilities to Hyperscalers data center developers, to really think about how we address this issue holistically for air and permitting. Voltaic is indeed focused on how we can use to potentially streamline the permitting process.

We're working with the 13 agencies in the Permitting Council signing milieus, including with the Chip's office, to potentially use this, which is still in beta testing mode. So right now we're really looking at, for example, when you look at a site, you know, has there been a study in this area before? What has changed over time? What are easier ways that we can quickly get to retrieve information from prior NEPA studies, which typically in the past would be, you know, a 200-page report that would go in a binder on the shelf. So how do we actually make that useful? I think a previous speaker spoke about even bigger challenges at state and local levels. And I think there's even more variation across states and localities in terms of different kinds of ordinances, for example, for charging stations or for wind turbines or other. We think that there's a lot of opportunity to potentially apply this to other areas. But this is going to be a program of work that we really develop further on later this year.

PATNAIK: So that's super interesting. So your plan down the line to also make this available to states and localities?

FU: We hope so. We hope that this is going to be useful for a wide variety of stakeholders because we think this issue is not going away. We need to find a way to get more energy onto the grid as quickly as possible. Of course, it's only one piece of the entire puzzle, right? There's going to be interconnection. Of course, we're going to need to think about how we bring and address the regional nature of this challenge, because as you know, it's not every part of the country that's experiencing this increase in data center demand. There are specific localities that really need some attention.

One of the things that our secretary and the department has been very focused on is how we bring communities along side. And the White House convened in September a number of federal agencies, a number of the big air companies and utilities to really talk through this issue. And one of the things that folks at the Department of Energy have been looking at is looking at retired or retiring coal sites that that could be used for redevelopment. So this. Is something that our Office of Policy has been leading on. But still, there's a lot of opportunities across the department and a lot of attention that's being placed on this very issue. I'm happy to send some resources afterwards to post because I think I think we just need to make that much more visible and much more well known.

PATNAIK: David. Back to the to you on the technical issues, when you look at the energy transition, what are some of the main challenges we face at the technical level?

BROWN: Yeah. So I think some of the things that we're facing, you could break it down into sort of predictive challenges. And I'm going to focus my questions going to be because there's lots of technical challenges related to finding alternative fuel sources, finding longer duration batteries, you know, many, many other challenges, you know, harvesting minerals more efficiently, recycling. I'm going to focus more on sort of the algorithmic challenges, if that's okay, and focus on energy systems. So I would break it down first thinking about sort of predictive challenges and in terms of getting better models really for predicting both weather and climate. And so this has been a huge area for AI, but there's still room for growing here.

So part of the challenge, of course, is that there's this kind of, you know, climate change is making predicting weather patterns more difficult. And so air models have shown tremendous promise there for weather modeling, but predicting these extreme events that really aren't present in the datasets, that's just a fundamental limitation. So I think that that's a challenge. I think there are certainly technical challenges related to just understanding the distributed nature of energy systems as we move towards virtual power plants, as we move towards, you know, the grid getting bigger and bigger. You know, we've got something like 55,000 substations in United States, and now we have challenges related to, you know, measuring, you know, power flows on every basically node of the network. We have smart meters.

So there's just a tremendous data challenge there. And then I would also say kind of kind of in between these things like thinking about, you know, also dispatch decisions, which are two talked about kind of optimization decisions there, how you deployed the resources there in the short term and how you control those operations smartly, but also longer-term capacity planning. Those are, you know, resource allocation decisions that we have to think about longer term. And I think those are really challenging questions like thinking about where we should be in investing in expanding transmission line capacity, thinking about the utility, should there be expanding solar or should they be expanding storage?

And if so, what's the right mix there? When do we retire Coal? We know we need to do it, but how quickly do we do it? Trading off. You know, that could in the short term create other challenges, Right? So I think those will be some of the big challenges. And then higher-level kind of maybe again, kind of in between these things is sort of predicting human behavior is a huge challenge. And so can we use these tools to do things like demand response pricing more efficiently and doing things that can be a vehicle to grid technologies I think is really a big challenge we have right now. And also thinking about system operators and electricity markets and kind of their strategic behavior and their had auctions and things like that. So I think those are kind of the big kind of tactical challenges, kind of, again, broadly related to air and energy systems that I would highlight.

PATNAIK: And would you say the U.S. is kind of like ahead of the curve in like exploring these or solving some of those challenges? Or are there other countries that are doing better than us afterwards?

BROWN: So I think I yeah, I don't know that I have a great answer to that question. I can't say we're necessarily ahead on those things. You know, I think if you look at weather forecasting models, I think the NOAA, you know, doing that for a long time. But of course, the European models are used all the time. And I think we're seeing a lot of progress in that.

Yeah, I think part of it, of course, we're faced we're bottlenecked by policy implications and how things go in the US and of course we know that's a challenge and there's lots of trains with changes, transmission risk associated with that. So yeah, I'm going to punt a little bit on that question, but I think there's a lot of opportunity for growth there.

PATNAIK: And Himanshu, staying on the technical aspect, what's the technology that is underpinning climate, air? And how is it different from previous technologies that have been used for analytics, for risk modeling?

GUPTA: Or. And before I can take a step back and I think highlight the importance of the project that Helena talked about and of course, she and I would get in and speak at a media conference as well. So when I was in the government of India and we were preparing the National Solar Plan, this was in 2013 and '14. And we called up the meetings of all the key developers in the government, along with the major corporations and us in India and of course the foreign companies in the US wanting to get into the renewable energy boom in India. The number one concern all of them highlighted is that permitting for their projects in India as well.

So, so I'm very excited about that. The project that Helena is leading at BOE and it shows us progress. It has a lot of global applicability as well in activating deployment of renewable energy into the grid. So back to back to the technical challenge that you talked about, Sanjay. We also look at like any climate problem as both the big data is going to the lack of data problem, right? Yes, of course, is, you know, we all understand like there's a lot of data coming from satellite, answers from radar stations, from weather stations and so on and so forth. And can the machine learning models crunch these numbers? And I think, as David talked about in a physics driven way, to create instances which were not possible before using the deep learning models are transforming models today. Yes, that's one aspect.

But I also want to highlight the other aspect is the lack of, you know, if you look at California, what is Alabama? California has spent literally hundreds of millions of dollars into creating a great weather station, infrastructure, radar station infrastructure inside the state, and also spent millions of dollars in to create a high-resolution weather forecasting infrastructure model local to California. And there's a federal model for weather forecasting produced by the National Weather Service.

And the rate is higher than Newton, which is low resolution and is high resolution model produced by California. But then what we realize is that as you are trying to exploit our work outside of the U.S. and let's say in Africa and India is not all these countries have invested that much money into creating that high density where the infrastructure to be able for these machine learning models to do well in terms of forecasting. So one of the approaches that we apply say like, hey, can we use the Deepfake technology, as we all know do that is used to create that we are nothing but generative models that are used to create fake videos or fake images, which looks as good as a real image.

So can we use the same approach to create a fake image of a high-resolution precipitation forecast, especially extreme precipitation forecast, learning from the weather station and kind of like learning from the models in California and see that this works in Alabama. And to our surprise, what we also what we realize is that that model. Creates for cars, which is as good as if Alabama were to create its own weather forecasting model. Right. So for us, you know, there's a lack of the problem that I was able to solve in this case. And we realize that if this is successful in Alabama now, how do we how do we translate that to other countries like, you know, Africa, where they have not invested in training, they don't have hundreds of millions of dollars to invest in high density with infrastructure and weather forecasting models.

So for us, of course, as you talked about, the next one is can we use it to crunch this big data problem in a predictive in machine learning? I talk about that later. And the second is, can we use AI to go around? This lack of data problem that we see in some of is on the forecasting application, not just weather forecasting, but also populating its impact into specific, you know, metrics that businesses and governments care about.

PATNAIK: Great. I mean, that's a really important and interesting angle because oftentimes, as you say, in those countries and areas of the world where we have the biggest impact of climate change, we don't have the resources to necessarily deal with it and adapt to it. Helena, I want to talk a little bit about something that came up in the previous panel, and it's also very striking whenever you talk to tech leaders on the West Coast, they always talk about abundance and the nature of abundance that is going to usher in for all of us.

One of those aspects is we need abundant energy to do so, right? And so what role do you see for AI to actually help provide cheap, clean and abundant energy because there are no silver bullets. Right. And so I think oftentimes there's a bit of wishful thinking when we look at kind of like how can we meet all our demands for energy in the next couple of decades?

FU: Yeah. And I think if you if you're looking at this issue, you're not thinking in terms of decades. You're thinking about what is the next five years look like. And that's a very short timeline and energy speak. So we have been doing a lot of thinking around what we can do in the in the short term, things like grid enhancing technology as we conduct touring, finding ways to develop new kinds of clean tariffs, to incentivize more energy coming out, but don't require the long lead times that permitting might require. But also looking at the newer technologies that are going to be needed. The U.S. has put out a series of reports, pathways to commercial liftoff. We've also put out a resource adequacy report that's looking at the energy demand and the things that are going to be needed to meet that energy demand.

Our Office of Cybersecurity, Energy Security and Emergency Response have been very, very engaged with the energy sector to look at the potential benefits and the risks that I can pose to the grid, because these are data centers are large loads that can be used and they can be used maliciously. So we really need to make sure that the lights stay on, that this critical infrastructure, that power, so much other critical infrastructure is maintained. So all of these things are key focus areas for the department right now. But abundance, you know, we are very excited about the opportunity for AI, for energy. And in fact, our national labs earlier this year put out a report that looks at the potential application space from subsurface monitoring discovery of new critical materials.

We actually one of our national labs, Pacific Northwest National Lab, developed a partnership with Microsoft to look at the universe of possible materials and then narrowed it down in a matter of weeks to develop a new type of battery that uses 70% less lithium, which is tremendous, and then fabricated it and tested it. So I think the key thing is not so much is the battery in production because this is still in the sort of basic science stage, but it's about speed to discovery. And I think that speed to discovery relates to, you know, more broader scientific breakthroughs, but also to the energy sector writ large.

PATNAIK: And so U.S. also funds research and supports research, Right. What role do you see for the U.S., kind of like in funding innovation in AI? Not necessarily in energy, but in air? Yes.

FU: And we do fund research. And I in fact, Doe has a very large part of the budget in our Office of Science that maintains well, and they do a lot of investment in basic science. But I think one really good example to point to is how we got to these three fastest supercomputers that I talked about a little bit earlier, because ten years ago, the road to getting to this exascale level of computer was primarily an energy efficiency problem. We could not figure out how to develop computers that were big enough and fast enough and still afford to maintain them. And so at the time, ten years ago, what did we did was not look at what was technically.

Possible deal, we set a target of what we are willing to pay for the energy of the life of the supercomputer and then divided by five, which is generally the life of the supercomputer. And that's how we got our energy target. And it was in deep partnership with companies like Nvidia, with Intel, with HP, AMD, that we were able to develop these fastest supercomputers in the world, which also had the benefit of developing key components of today's GPUs. So I think that's a really good example of the kind of role that public investment in public private partnerships can make to really change the game. We would have gotten to this stage of energy growth so much faster if we had not been able to drive the energy efficiency gains in computing to begin with. And we think that there is a whole universe of energy efficiency in algorithms that we are also investing in right now.

PATNAIK: And the theory going back a little bit to the question that I asked David earlier. Do you guys exchange information, best practices with other governments around the world?

FU: Yes, absolutely. I mean, we have very robust international collaborations. One thing I would also flag is that our Lawrence Berkeley National Laboratory has a congressionally mandated data center energy efficiency report that comes out every few years. The next instantiation, which is probably going to be the most widely read report, is actually coming out later this month. So just wanted to flag for the group. We're really excited.

PATNAIK: About what to look forward to. Yes. David, when you look at kind of like improving energy systems and using air for that, what kind of algorithms and techniques are we talking about and how is that different from the large language models that we all know with try to beat by the conventional algorithms that we've seen before?

BROWN: Yeah. So I love this question because it really gets me to nerd out a little bit. So first step back a little bit. What is a large language model? It's kind of mystical now. It's this powerful, just nebulous thing. We just type something and magically something appears. There's tremendous engineering and sophistication there, but at its core, it is a class probability estimation model. It's a large neural network. Given a sequence of words, give me a probability distribution on the next word in that sequence. So it's a classification algorithm, essentially. So what's one similarity? I see And a lot of what I was doing in energy systems, a lot of the best predictive models are based on neural networks. So the underlying kind of architecture and machinery is kind of using similar tools. I would say kind of some differences.

However, if we look at large language models, what we're typically thinking about is language data, right? Which is unstructured. A lot of the data in energy systems is much more structured. Just looking at system loads, demand for electricity, TV production, whatnot. Now there are exceptions and one exception was literally with satellite imagery, and that's come up in a few different panels. We're seeing a lot of algorithms based on, you know, using convolutional neural networks to basically process, you know, image data and measure things like greenhouse gas emissions. So we've got an organization, climate trees, we've got cow, cow. Bradbury at Duke Nicholas Institute is also going to be part of that, basically looking at, you know, predictive techniques for that satellite imagery data.

But then there's one other thing that's kind of interesting twist here is that what we're hearing with we heard this in the previous panel is the large language models, the, you know, you know, load growth, explosion, all the energy we need. Actually, it's the opposite when you look at AI tools in some sense for building like for models that are coming out there is that it's they're kind of actually getting around all the energy usage of the more traditional models like the physics-based models, which if you think about simulating a century that can take, you know, something like, you know, ten megawatt hours and it could take weeks to simulate on supercomputers. Now, with AI based models, actually we can do that much, much faster, millions of times faster. And so that's kind of an interesting parallel to everything that's going on with large language models.

And that's a hopefully a comforting thing, thinking about energy consumption. And the flip side of that, that's really interesting. And this is a parallel with, I think everything we're seeing with large language models is the open source paradigm is because now these models are being developed and they can be run on someone's laptop, for example, whereas before only the NOAA or something on their supercomputers can be running these. We're seeing kind of an opening of doors here to open source models where you can have many, much smaller organizations and even individuals, academic researchers running these kinds of models. And there's a huge, you know, potentially spillover of positive spillovers there. So I think that's kind of, you know, how I would think about that. You know.

PATNAIK: That's a very interesting angler to bring up here. And the open source debate is a big one in the AI community, as we all know, because of national security concerns. And they're like different camps among the tech firms. Helena, how do you think about that, the open source? What does the deal we look at? Because the deal is also a concern with national security, with protecting our secrets. What do you guys look at when you look at open source?

FU: I mean, we so do we is an R&D agency that is really uniquely situated in the federal family because we are a science and technology agency. But we do span from open science through national security applications. Obviously, you know, we support open source technology, our Office of Science. You know, we have a lot of things that we have made open source. And, you know, many federal agencies are all working on open science. We have directives there. But we also see some potential risks from data that, you know, may be particularly sensitive.

And so we have been looking at what we need to potentially be able to do. We've been evaluating open source models as well as proprietary models. Our National Nuclear Security Administration, in fact, for the last year has been looking at what these models may mean in terms of nuclear threat information and their ability to collect information from all across the Internet and whether or not that changes the threat environment. So that's something that we have been actively looking at for some time.

PATNAIK: That's a difficult balance to strike right now. Himanshu, I want to take a step back. And so you're coming at it from the private sector, right? Like, what role do you see for the private sector to help solve the climate crisis? And what support do you think would be most useful from policymakers and from the government?

GUPTA: I think number one is going back to this point. Just let it be all open source. No, you know, of course, there are applications like nuclear and, you know, national security applications where one could think about developing proprietary models, you know, which are so procured by DOD or whoever else. But we all but look at it this way. We all take a lot of pride in how, you know, societal transformation. Mobile phones have been able to bring in emerging economies. We have big examples of India, Thailand, even now in Africa. Right. Where people are getting deeply connected is bringing societies around, transforming societies. Now, imagine if Android was not an open source operating system. Would we have? Would we have seen such upward proliferation of smartphones in the developing world? If you you're still relying on iOS?

That's something to think about, right? So I think of computer applications as basically it's a it should be a public utility and as is electricity for developers to come in and start building applications on top. And that's where I feel like we are is spending too much time on debating between open source. What is surprising I do not think we are on a stage where we have seen enough proliferation and enough people getting like enough developers globally getting connected. And so as an example, even if you look at ERP systems of 2000, right? ERP. I'm talking about Oracle and that suite, the CNF system that they built in early 2000. What has been the penetration of those systems in the enterprise world? Any guesses? It is.

These systems came up in the dotcom during the dotcom boom late 1990. Components less than 40%. Less than 40%. Right. So we sold the companies that we used to work with, like in manufacturing and agriculture. They are still operating on excel sheets. What is operating on them systems and not. Right. And so that's that that you know. So I feel like the as an entrepreneur and myself I think there's and we should we should focus a lot more on basically helping developers build applications. The top of inference models on top of these open source model and not have any regulations come up except for a few applications like nuclear and national security applications, where I think DOD or whichever government can procure proprietary models from existing vendors. So, so that's, that's one and I'm my apologies. And I forgot the middle part of your question. Maybe like in industrial time you know people to more.

PATNAIK: Know probably maybe if they would like you can chime in on this when we look at policy incentives right in making supply decisions what kind of like role should policy makers play and how do you see the incentives from the IRA? Are those effective in actually incentivizing supply and the supply we need?

BROWN: Yeah. So I think policy is essential. We're not going to get there if we talk about net zero with just technological solutions because there are so many different four fronts. You know, it's not just making utilities operate more efficiently, efficiently. There's also agriculture in the transportation sector and making our production processes more efficient. I think the Inflation Reduction Act has been beneficial. I don't think anyone, you know, even the drafters of that, the intent was that was going to fix everything, really. That was a stimulus to get, you know, private capital. Has it done enough in that regard? I think the jury's still out on that, but I think it's a step in the right direction. I think there are things like fundamental valuation questions that policy can help with.

And, you know, coming back to grid, you know, expansion, you know, we're looking at maybe $25 trillion of expansion of the US electricity grid by 2050. How do we think about, you know, how do we think about that when we're thinking about, you know, trading off that versus expanding transmission line capacity versus microgrids?

And how do we think about value in that when you're talking about, you know, local regions that are connected to, you know, hospitals and schools and things like that, how do we make those wrestle with those valuation questions? That's where policy should really be making a difference. And so, you know, I do think, you know, if you look, again, coming back to utilities, I think, you know, we have a FERC expert on the previous panel. But, you know, if you look at FERC 1920, that's really forcing, you know, balancing authorities to think longer term in their capacity planning. I think that's something that's really good. And so hopefully that will help. I think I think the silver lining of all this kind of the huge economic value from I guess coming back maybe to the previous panel is I think this gives us strong economic incentives to kind of hopefully expand renewable capacity. I think policy is going to be essential in kind of doing that.

PATNAIK: Moving it along record. Great. Helena, two questions. That kind of like one related to the audience and one also on the role of policymakers. I think oftentimes the concern is when we look at government and the tech industry to attract the right talent in government in especially because they obviously pays a lot in the private sector and this usually the government cannot keep up with that. How do you view this? A duty to attract the right talent to actually keep up on the market trends. And then this relates to someone in the audience. How do you see kind of the next administration, kind of like what kind of changes do you expect or not expect to happen?

FU: So I think on the first question around workforce and talent, this is something that obviously D.O.D. is dealing with, I'm sure many institutions are dealing with because we cannot pay the salaries that the big companies can pay. But I think for D.O.D., if people come to do it for many reasons, pay is one of them. But I mean, the key has been the mission. And so we have over 40,000 scientists at our national laboratories, chemists, biologists, physicists who are really committed to doing science for the public good. And I think what is helpful is that we have other things to play with or use, like the infrastructure that I was talking about. Some folks come to DC because of the very unique laser that we have or the supercomputers that they get to use.

And I think that's an important part, right? Is the unique facilities attract talent. But I think public investment and continued investment in that kind of infrastructure and in the kind of capability agency that Doe is going to be important moving forward. I can't opine on what the next administration will do, but I think, again, just going back to what D.O.D. is as an agency, we really are an enabling agency for many other parts of the US government, some that you may not be so aware of, right. Whether it's, you know, helping to model the Mars rover landing or working with VA on veteran's health or climate modeling with Noah. These are capabilities that DIA we nurturers at DIA in the national laboratories for the country. And I think moving forward, we are going to need to find new and novel ways to partner more aggressively than before with academic institutions and with industry, because I think the only way that we continue to maintain our leadership in AI is to be able to do that.

PATNAIK: Well, that's a great point. We're almost at the end. So very briefly, each one of your brief kind of like key takeaways that you want the audience to go home with today. Himanshu, let's start with you. Main key take.

GUPTA: My key takeaways like I'm remember from a former policy I I'm a former policy planning policy maker. From that standpoint, I feel very pessimistic about, you know, from 2014 to now forget any reduction in emissions. We are not doing the reduction in base of emissions since Paris climate Accord, where I was deeply involved in modeling emissions for India. But as an entrepreneur, I feel very optimistic as well. And the role of I come to think of it, when the pandemic started in 2020, we went from having no knowledge of the COVID virus, like literally no knowledge of COVID virus to developing deploying 5 billion vaccines globally within 18 months.

Why can't we and why can't we do the same for someone whose planet problems that we are seeing? What is not working? And that's something that we to think about. It's definitely not it's not technology. It's definitely not funding. There is some funding available. Of course, we can only see like how can we deploy more funding towards life and climate friendly coming in. I already did something else in that spa. I always think about that and for all of us to think about what is not working here, we have solved your ozone hole problem. Why are we so delayed in solving the climate problem?

PATNAIK: Great. Thank you, David.

BROWN: Yeah. So I guess a couple of things really quickly. So first, I would say not to dismiss the need for regulations and the ethical concerns. I think we should not be afraid. I think we should embrace it as something that, you know, is could be a force for good. And then kind of coming back to that point, I would say thinking about education. And I would say even earlier than, you know, you know, higher education, thinking about, you know, the Duke University's of the world, we're going to be facing a tremendous talent shortage in the energy sector. We have roughly half a million employees.

A lot of that is in oil and gas. But we've got an aging workforce that's going to be retiring over the next decade or so. And that's a huge opportunity with these new technologies to do something great. And so I would start education, kind of think about primary school education and get kids in this country excited about these technologies. And I say this as a father of two boys, my ten-year-old son refers to me as net zero, bro. So I'm so I say that. So, so thinking about policymakers and investments, I think investing in education and these tools is really important.

PATNAIK: I love that point. That's a very unique approach to it. Helena.

FU: I think that we're really excited. I think this moment, both in terms of what I can do for energy and the grid broadly and, you know, the opportunity space. I mean, I want to go back to the abundance point earlier, really to use this moment to catalyze an energy for AI, not only for AI, but also for manufacturing in the States and broader electrification goals. I think we're really at that cusp where we need to address both of these and need to do it at scale, and we're really just happy to be here and part of this conversation as we move forward.

PATNAIK: Great. Thank you so much for the outstanding panel and for your viewpoint. Thank you.

CHATTERJI: Okay. I have the opportunity now and the honor to just thank all the panelists and the fantastic collaboration between Duke and Brookings. I'm Ronnie Chatterji at Duke University, speaking in that capacity today. Since this is organized way before all this happened to me. But the reason we put this together is to kind of highlight what you saw today.

The opportunities and the challenges. And the two panels somewhat seemed oppositional at the beginning when you saw one talking about the challenges and the others with the opportunities. But in the day, I think you saw optimism on both panels, both in terms of trying to solve some of these challenges. And ironically, Helena's remarks were relevant to this. Some of the opportunities and challenges are co-mingled. So if you think about NNEPA, for example, this point about, you know, that Zach brought up many times about NNEPA and reform of NNEPA being tied to now this project to tokenize NNEPA, to give that as an open source model to people to play around with that and figure out where it can be improved.

And so I think you're going to see a lot of this duality throughout these topics as we go forward. The reason we wanted to bring Duke and rookies together is because we don't think that one institution can solve this on its own. And so it took a collaboration like this to have a diverse set of panelists and perspectives. I also think it was notable that we had folks from the regulatory side, business and academia coming together. It was somewhat daunting during some of these discussions to think about how many innovations have to happen simultaneously across how many different sectors. And I was counting the hardware and software piece, designing better chips, better data centers, thinking about sort of connect. All that to the grid. New sources of energy from small modular reactors to bring more wind and solar and storage online.

And then I thought about even the innovations in finance that were Florian from BlackRock talked about. Private credit has been booming recently and is one of the biggest funders and financiers of these exact infrastructure projects. So if you think about that, even short of all the government innovation that needs to come into play, yes, the federal government, but often that was emphasized on the first panel, state and local government as well. When you put all that together, you might come away thinking, my gosh, how are we going to do all this? But I think that the innovation and entrepreneurship spirit that was embodied in the last panel and throughout, it's not going to be one lever that can be pulled here. There's going be a bunch of decisions working on this, maybe sometimes in uncoordinated fashion.

And I want to say just three things at the end to wrap this up. And then and close this out. One is flexibility is really important. One of the things I did my most recent role in government was implement the Chips and Science Act. And I was also alongside the implementation of the Inflation Reduction Act. Now, I can tell you that the words I didn't come into the Chips Act and the IRA until much, much later. We designed the Chips Act to solve a problem about ongoing domestic chip production, not to win the race for AI, but to make sure that we could have computer chips for our phones right, for our medical devices, for the grid. Now, the conversation about chips is all about AI. We talked about the incentives for the Inflation Reduction Act.

We were thinking about climate change, fulfilling some of the promise, the amount you talked about, the heat worked in India. We weren't talking about the energy use of AI, which is now become a dominant issue. And the reason that we talked about the inflation reduction today. So that flexibility meeting, that can be really important. We had a lot of solutions today, and I'm sure there's lots of things we haven't even thought about. So we're not even asking the right questions. We have to keep following that. Second thing is the geopolitical dimension. I think probably if we do another version of this, we should do something on the rest of the world. This was very U.S. focused by design. But one thing I'll say about sort of the competition here, the infrastructure spaces, other countries are having these same discussions, some with some of the same permitting challenges that you see in the United States, some without those challenges and different sets of challenges.

Where is the infrastructure to power this new generation of technologies going to be built out? And the U.S. now has both the national challenge of doing it here, but also global challenge related to climate change. That's going be something interesting to watch. I think we should focus on in the future. Lastly, I want to say we keep doing events on these kind of topics, both here at Brookings and also at Duke. In April at Duke, we'll have our second annual Billions and Trillions conference, which talks about how to unlock climate finance for exactly these kinds of solutions. And looking forward, we'll do more projects around deep technologies at Duke, both quantum synthetic biology, generative AI, and of course, going back to advanced microprocessors and computer chips.

For now, I want to say I just want to thank the panelists for both the breadth experience, but also the depth of their responses. It was really great to see this expertise out here. I also want to thank the audience for your questions and engagement. Thanks, everyone, for being here and we'll see you at the next event.