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THE ENERGY CHALLENGES OF TAIWAN AND ASIA'S AI AMBITIONS

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INTRODUCTIONS

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HASS: Good morning, friends, and welcome to today's event on the energy challenges of Taiwan's and Asia's artificial intelligence ambitions. My name is Ryan Hass, I am the Koo chair in Taiwan studies following Richard Bush, as well as the director of the China Center here at Brookings. And I'm extremely proud to be co-hosting today's event with our wonderful partner in Taiwan, the Center for Asia-Pacific Resilience and Innovation, often known as CAPRI and the CAPRI USA Foundation.

I want to intentionally maximize the time available to hear from our experts. So I'm going to be deliberately brief in my comments this morning. I'm just going to make three quick points. First, reliable, sustainable, and secure energy systems are key for any economy that wishes to become a leading AI hub.

Second, Asia is not a monolith. Each national condition is different. Those of us working in Washington need to understand how Taiwan's and the region's AI ambitions intersect with the security energy and governance challenges that they face.

And third, I can think of no better partner in the world for developing a more nuanced picture of the policy debates taking place in Asia and in Taiwan around these questions than my friend Shirley Lin.

Shirley is the founder of CAPRI. CAPRI is a non-government, non-partisan international organization working to enhance global resilience and promote innovative policy by drawing on experience of the Asia-Pacific region through comparative public policy research. With that, please let me turn it over to Shirley.

Thank you.

LIN: Thank you, Ryan. It's so great to be back at Brookings, where I have been working closely with Ryan and his team as a nonresident senior fellow. To return as a partner is wonderful because the times are challenging. As the founder of CAPRI and president of CAPRI USA, I'm delighted that we have this opportunity to improve the relations between Asia-Pacific and the United States to find ways to tackle the biggest policy challenges of our times.

As Ryan has already mentioned, we're founded in Taipei to draw on the experience of the Asia-Pacific, and today's event is a wonderful opportunity to showcase what Brookings and CAPRI have been working on. This is our third event this year. CAPRI hosted Brookings experts in Taipei twice this year to talk about the geopolitics of tariffs and trade.

CAPRI’s research and programs look at the intersection of four themes: health resilience, economic dynamism, energy and environmental sustainability, and finally, transformative technologies. CAPRI and CAPRI USA are very proud that we've developed a partnership that will be able to meet the challenges. Today's panel is at the heart of our work cutting across several of our research initiatives.

We've recently launched a four-year project to examine policy trade-offs, as Asia-Pacific countries pursue energy security, energy sustainability, and new drivers of economic growth. As demand grows for AI and data intensive technologies worldwide, and competition for technological transformation intensifies, Asia-Pacific democracies are trying to balance energy resilience with economic and technological ambitions, not to mention climate resilience. Taiwan feels the challenge of balancing these trade-offs intensely in the Asia-Pacific. It has grand plans to keep up its economic competitiveness by doubling down on boosting its AI capabilities.

But where can the island find enough energy to power its AI economic revolution, and maintain climate resilience? Our speakers today will provide a variety of perspectives on this issue. David Edelman is bringing his policy expertise on digital disruption and AI governance. I want to especially thank Gary Dirks, who joins us all the way from Arizona State University to share his deep expertise in the Asia-Pacific energy industry and how it informs his current research and work on sustainability and energy policy. Tarcy Jhou joins us online from Tokyo at 11:00 PM, where she covers Taiwan and the APAC region at the Asia-Pacific Energy Research Center. We're delighted that this conversation is moderated by Samantha Gross, a true expert on energy security and climate with over 25 years of experience in energy and environmental policy working across both United States and international energy policy, she will undoubtedly navigate this complex and nuanced discussion with skill.

Before turning over to Samantha, I have to thank this wonderful partnership. Both the Brookings and the CAPRI team worked very hard to put this event together. Despite the snow, I came and it is very cold, so we know that climate change is real. It is not possible without the help of Jennifer Mason, Adrien Chorn, and Siwei Huang and Rachel Bernstein from the CAPRI team in Taipei.

Thank you, Samantha. Over to you.

GROSS: Good morning, everyone. I'm happy to see so many people got up early this morning, put on their gloves and their hat and made it. This is going to be an interesting conversation. I'd like to thank Ryan and Shirley for their kind introductions. And also, Shirley, thank you so much for your partnership and we really appreciate it.

So, we've gotten through the intro, so I think we should just dive right into the substance. Gary, I'd like to start with you. Why are we so worried about data centers now? I mean, this crowd here, we have a ton of data centers in in Loudoun County. What's different? Why can I not go to an energy conference without hearing about data centers and AI, like, in the first sentence?

DIRKS: Great question. Let me start by thanking the Brookings Institution and CAPRI for this opportunity to speak here today and for getting me out of mid-seventies, bright blue skies to something a little more bracing –

GROSS: Sorry, Gary.

DIRKS: -- to start my day in particular. Like I said, the question is great, and I'm coming at it from two perspectives. First, I am at Arizona State University, and Arizona is kind of an epicenter for data centers. We have about 125 centers in the metropolitan Phoenix area, we have requests for connection in five years or less for about 40 gigawatts of additional data centers. And to calibrate you, that is more than one and a half times the size of our current electricity grid. So, it is a very live and very real conversation for us.

Second, as you heard from Shirley, I was with British Petroleum for 34 years prior to going to Arizona State University in 2009. The last 14 of those years I was in, in Beijing. And while we were there, we ran a whole array of energy assets and built quite a number of them as the lead partner.

So, for example, we built a big LNG terminal export terminal with gas fields in Indonesia. We built the Shenzhen receiving terminal in China, and some major assets in Vietnam. So, it has been a conversation – energy in Asia – for me for a very long time.

Let me begin by saying I'm a bit of a techno optimist, so I believe there is real opportunity for data centers going forward and say that to my students. But immediately follow that by the challenges [which] are really extraordinary. And they are extraordinary because there is no place on the planet that is shovel ready to take facilities of the scale we're talking about. And we heard that alluded to earlier. What's changed in the last several years is a big data center has gone from being about 50 to a hundred megawatts to 500 to a gigawatt.

And now we're talking about campuses that could be 2, 3, 4 gigawatts of power. No place on the planet can deliver that kind of power to a place, no place on the planet has that kind of spare capacity in the grid. And that's just for the electricity. That doesn't include water, fiber connection, and the land requirements associated with these things.

And they're not passive infrastructure, as a lot of people would like to have you believe. They vent a lot of heat, and they can be a little bit on the noisy side. So, they stress our physical infrastructure, which means they stress our institutional infrastructure. And that for me is the fundamental challenge.

How do you integrate the physical infrastructure along with the institutional capacity to get in one place, what you need to be able to support infrastructure of this scale? And I'll pause there.

GROSS: Yeah. Gary, you told me a fact last night about heat coming off of data center properties that blew my mind. Can you share that?

DIRKS: Yes. Well, one of the things that a lot of folks don't think about are the thermodynamics of a data center. I'm sure that's on everybody's mind here. But if you are putting 300 megawatts into a data center, it's important from a physics standpoint to recognize they do no work. They do no work. So that means every bit of energy that goes in must come out. And the way it comes out is in heat. So, a 300-megawatt data center is putting out 300 megawatts per hour of heat. We've been measuring in the Phoenix metropolitan area. It's preliminary, but we've been measuring the plume, the heat plume off of -- and this was not a big one, this was about a hundred-megawatt data center. 500 yards away, it is already still raising the external temperature by three degrees Fahrenheit, which doesn't seem like a lot, but in a big neighborhood in a place that's already hot. The utilities are really interested to know about this because they're going to see another spike, not just from the data center, but a spike in the neighborhoods.

GROSS: …air conditioning load. Yeah. That was absolutely fascinating to me. And I'm an engineer. Tarcy, I'd like to turn to you to talk about some of the specific challenges to Taiwan's electricity sector. How does tech, particularly the semiconductor industry, and perhaps the upcoming AI industry, fit into Taiwan's electricity sector?

JHOU: Hi, Samantha, thank you for your question. For the electricity challenge, we can divide it into the energy benchmarks: affordability, reliability, and sustainability.

For affordability, because Taiwan is just an island and most of our [Taiwan's] energy relies on imports -- around 97% are all imported -- which means that a problem is global fuel prices. And because we [Taiwan] just phased out our nuclear power plants and are going to

use natural gas to bridge this gap, it causes another problem for the infrastructure, for the affordability, and also the cost for the fuel.

And then the reliability. Because as I mentioned that we phased out our [Taiwan's] nuclear power plants and we [Taiwan] are going to develop renewable energy. So, in the future, we [Taiwan] need to ramp up our power around 20 gigahertz for ramping capacity per hour. The main reason is because Taiwan has lots of potential for solar PV in summer. But that's just during the daytime. So, in the evening, we need to ramp up the power immediately. That will cause another challenge. Another problem is Taiwan's electricity markets are still largely centralized. Taipower oversees generation and transmission, as well as the distribution and the systems operations. And even as IPP [Independent Power Producer] contributes meaningfully, Taipower is still responsible to maintain their reliability. So, this means that if we would like to manage the increase in electricity demand, Taipower plays a very important role.

Another issue will be sustainability. That's because Taiwan has an ambitious target for renewable energy and natural emissions, which means it also causes problems for renewable energy generation, for the intermittent problem. So, this is the three approaches.

And also, because the electricity consumption from, like, TSMC consumes around 6% to 8% of the total electricity in Taiwan. And for the total supply chain for semiconductors, it consumes about 20% of [Taiwan's] electricity consumption, which means that they don't just play a very important role for our [Taiwan's] GDP, but also that they are a major consumer of the [Taiwan's] electricity. So, it will be a major problem for the energy situation in Taiwan.

GROSS: That's such an in interesting fact. 20% of electricity demand goes to the supply chain and operation of one industry. So, David, I'd like to bring you in to talk about, what are the attributes a country needs to be a relevant player in the AI space?

EDELMAN: I think it's important that we also take a moment just to recognize the speed at which this is coming on and why we're suddenly asking this question. Gary, I think –

GROSS: Yeah, we're going to go there.

EDELMAN: -- you raised this in a moment but recognizing, for instance, the number of months it took for ChatGPT to get to a hundred million users was three months. Any comparable technology to date -- 30 months, I think it was for Uber, it goes longer for Instagram, et cetera. You think about these broad technologies, immediately, condensed cycles. And so, you know, I -- recovering government official way back in the day, 2013 when we wrote the US government's first AI strategy -- this energy piece in my mind was the missing piece of it. And now, you know, as we talked about, we measure data centers in gigawatts. We don't measure them by energy, and not chips. This was a missing piece. And so, you know, we're about to talk about, what does it take to be an AI player in the energy space? And I think it's critical to recognize just how odd a question that would've seemed a decade ago. And yet here we are. It is the critical question.

So, you know, what does it take? All of these pieces come back to Taiwan in a really interesting way. You know, one of them of course is access and you know, you already heard Tarcy talk about access, in Taiwan, to energy that is not imported is a really material challenge, right? Making sure you have that access to the raw fuel going in. And we could talk about that, and I assume we will a little bit in terms of the fuel mix.

The second, which is really important, is stability, right? So, whether if you're training AI models, which some countries are, some countries aren't, it's very spiky, right? It requires a ton of data and then it -- sorry, a ton of energy -- and then it doesn't for a period of time, but inference, which is to say, us going on ChatGPT and querying it, using AI, is actually base load consistent strain on the grid. And so, one of the key measures we have to think about for an energy AI power for anyone who wants to be relevant is stability and the margin question. You know? And in Taiwan, you know, we read last year that there were times that the Taiwanese grid had 5% gross operating margin. If that's true, you know, you really want about 25% margin, wiggle room, so to speak, then that's a real material challenge for the long-term stability.

And then the third is resilience. You know, I read reports last year that successful incursions, so successful cyber incursions into the Taiwanese grid attributed to Beijing were up twofold. Just in one year. Now, you'll often hear folks at DOD and elsewhere measure cyber-attacks in terms of attempts. We had 10 million attempts on the DOD systems this year. That number doesn't matter. But successful incursions into a grid do matter. And so, hearing that those sorts of incursions doubled, what that tells you is that in cases of contingency or even political coercion, the potential to start flicking off bits of the grid, something we've seen the Russians do both pre conflict and conflict in Ukraine is really material.

And I think those are three pieces that come together in a really important way to designate whether a country can be, in a long-term context, actually useful as an AI player internally, and then if they ever have hopes of playing internationally as well.

GROSS: There are so many threads to pull out of those initial statements. But something I'd like to start with you, Gary, is one thing that strikes me about this is that the AI industry and the energy industry just have completely different cultures. This is a real mismatch and everything from timeframes to just ways of approaching problems. Can you expand on that?

DIRKS: Sure, I'd be happy to because I think this is really one of the central threads on what the issue is, and David has already alluded to that. When he talked about the timeframe and how fast we got to where we have with OpenAI and ChatGPT, if you go to a utility executive and say, I need in that place over there 500 megawatts of power and I need it within the next 18 months, they're going to look at you like you're coming from a different planet. And it's not because they're slow, and it's not because they don't understand the imperative. It's because that's not their world.

Just beginning to think about where will I get 500 megawatts? If I have to build a new plant, where am I going to put it? How long is it going to take me to get it sited? If it's a thermal plant, where am I going to get the water from? If it's a renewables plant, let's say 300 megawatts, or I said 500, so stick with that. It takes in Arizona about five acres per megawatt. So, if you want 500 megawatts, that's 2,500 acres of land you need to find someplace, which translates roughly into about four-square miles of land, and that's just for the name plate. Solar doesn't run all day, so now you need the reserve margin, that you have to build over on top of that. Then you're going to need batteries. It's just a mind-boggling effort. And I haven't mentioned transmission yet, because to serve a data center of that size, you need at least a 300-kilovolt line, if not a 500-kilovolt line.

That data center is going to require millions of gallons of cooling. If it uses water cooling, you just start adding it up and adding it up and adding it up. And the two worlds just simply don't have an overlap. Their Venn diagrams don't overlap. And that's why I made the point at the outset about stressing our institutional capability because it isn't as though you can just simply say no. Although cities are increasingly saying no in the US. There has to be a

solution, but most of the infrastructure to have the right groups of people talk to each other, the social infrastructure just doesn't exist. It has to be created on the timeline David was talking about. And so, we're seeing this clash of cultures, or more importantly two cultures that are just sailing right by each other.

GROSS: Yeah. And I would add even here in the US, the land of energy abundance as we're all hearing about these days, even with all the natural gas that we have, I hope you've already ordered the turbines to produce that natural gas. GE Vernova, one of the big makers of gas turbines for electricity generation, their order book is out to 2029. So that's not the fast solution people think it is either, even though the, the United States is awash in fuels.

DIRKS: This is a really good point. The entire supply chain is choked.

GROSS: Tight.

DIRKS: You can't get transformers, you can't get switch gear. You name it, you just…It's all backed up.

GROSS: So Tarcy, can you bring us back to Taiwan on this question and talk a little bit about the key challenges in Taiwan of meeting this potential growing electricity demand?

JHOU: Yeah, for the AI energy challenges, it's not just for Taiwan, it's also for the APEC regional economies, because AI electricity demand is so unpredictable. So for Taiwan, as I mentioned before, that's because we need to…we [Taiwan] are going to increase the renewable energy generation, which means we [Taiwan] need to ramp up around 20 gigawatts per hour. But if we [Taiwan] also would like to aid more [with] AI electricity demands, it means we [Taiwan] need to ramp up faster. This will be a major problem.

And another problem will be the fuel overload. That's because currently even though we [Taiwan] already just increased our [Taiwan's] LNG storage from 7 days to 11 days. But that's still not really enough, if we [Taiwan] would like to increase the electricity load. So, this part will be a major challenge. And also, because we [Taiwan] need to have a very [high] quality and a lot of electricity, which means that the timeline cannot match.

For example, building an AI data center takes two or three years to build. But if you like to build a substation and also the transmission, even just the LNG infrastructure receiving terminal, it takes around 5 to 10 years. For example, like in Taiwan, when we [Taiwan] would like to develop, build the LNG receiving terminal, we [Taiwan] still need to pass environmental assessments and need to have consensus with the public.

It's all long procedures, which means we [Taiwan] cannot develop certain infrastructure faster than the AI development. That will be a major challenge for Taiwan's energy situation.

GROSS: Yeah, and we saw in Europe recently in 2022 and 2023, Germany built an onshore terminal to accept a floating storage and regas [regasification], sort of an offshore LNG terminal. And they did it in nine months. But even those ships, those floating LNG terminals, let's call them, they're in incredibly tight supply too. Like the supply chain everywhere for everything is tight.

Tarcy, I want to stay with you for a minute because you're talking about tight margins and low storage of LNG, but I know all this happens against the backdrop of the phase out of nuclear in Taiwan. And so, I feel like that's a little bit the elephant in the room. Can you talk a

bit about the role of nuclear and the politics of nuclear in Taiwan right now? Could it help solve this problem?

JHOU: Okay. Maybe I can share some background information about the nuclear power plants, and what the policy is. Previously we [Taiwan] have nuclear power plants…the referendum, so we [Taiwan] already had the consensus, we [Taiwan] are going to phase out [nuclear power]. [As things stand] this year since May, we [Taiwan] already phased out [nuclear power]. So, so far [at that point], we [Taiwan] are nuclear free. But two months later, just in July this summer, we [Taiwan] started another discussion and another referendum, but the result is that around 70% of voters, they agreed to restart the nuclear power plants.

However, we [Taiwan] didn't pass [the referendum], because the result didn't pass the baseline -- we [Taiwan] need to have around 5 million voters [there were fewer], which means this referendum didn't pass. But it shows one thing that is very important. Those who voted pro-nuclear power plants to be restarted…it's already more than [those who] would be anti-nuclear power plants and would like to have a nuclear free [Taiwan]. So, I think this is one of the very important changes in Taiwan compared to two years before.

GROSS: Could you tell us how big is that nuclear power plant? Just to put it in the context of the big numbers we're talking about, of AI electricity demand. What's the generating capacity there?

JHOU: I'll say this. Nuclear power plants, they can't provide for the capacity [needed]. Because previously, if you would like to say capacity, I will say that for the share of the [electricity] generation, because two years before this, we [Taiwan] already started to phase out [nuclear], which means that the portion of the nuclear generation was already reduced.

But, if we [Taiwan] would like to restart a nuclear power plant, we [Taiwan] still need to pass lot of assessment, because they already passed a lifetime [nuclear power plant lifespan]. That's a main part. But so for nuclear power plants, they can provide a more stable power for Taiwan to reduce their problem. Especially like, if we [Taiwan] would like to rely on imported energy, we [Taiwan] will [run into] energy security issues. We [Taiwan] usually has typhoons in the summer, and if a typhoon is coming, sometimes it will affect the shipping time for LNG. That's one concern. Another concern would be energy security geopolitical concerns.

GROSS: Yeah, we're going to come back to that.

JHOU: So the plan—
GROSS: Definitely going there. David, I see you chomping at the bit a little.

EDELMAN: Let's go there, okay.

GROSS: Yeah, let's talk a bit about the nuclear shutdown. This is a tough circle to square.

EDELMAN: From where I sit, as national security guy and as an AI guy, the nuclear phase out in Taiwan was a gift to Beijing. Actually. I mean, to be clear, let's talk on the AI side. What do we need? Firm base load energy that can't be disrupted over a long period of time. High capex (capital expense), yes, but relatively low opex (operating expense). General stability. This is the kind of the reason why you're seeing -- for different political reasons -- in the US substantial attention to a nuclear renaissance. Even California in the United States is now having a similar reconsideration of its nuclear power posture, something I think many of us would not have envisioned 20 years ago.

The second piece is just that resilience bit that I mentioned before. You know, a nuclear plant in a really bad day can run for 12, 18, maybe 24 months on its existing fuel. It doesn't need a refuel, doesn't need those ships that Tarcy was talking about to bring the LNG in, doesn't need other sources. This becomes very material in a world in which, at a minimum you have global factors that can disrupt supply chains, and where you have geopolitical insecurity factors that could disrupt supply chains, it becomes wildly more material.

And so I think it is really worth double clicking on that referendum where, you know, 5 million some people, 74% said yes, let's turn the nuclear plant back on. I'm not pretending that nuclear power is costless. I'm not pretending that nuclear power does not have safety considerations, but when thinking, particularly in the Taiwan context from this side of the Pacific, that was a surprise.

GROSS: Yeah, we're in this situation and you see this in energy systems everywhere. I work a lot internationally and everybody wants everything. They want it cheap, clean, they want it growing, and they want it yesterday. And you know, we talked on the prep call for this, something has to give. And so, this is just a huge challenge and it's another reason why you see the nuclear renaissance here in the United States. We want carbon free based load power. And so, it's just fascinating.

The last thing I'll say about that is, the world is awash in hydrocarbons. We are not running out, we're not low on LNG. There's a bunch of new capacity coming online. We are absolutely awash in oil right now. There's plenty of fuel out there. The question is, can you get that fuel into your ports to use it? And Tarcy is describing moving from 7 to, I think she said 10 or 11 days of storage. That's pretty scary when you're living in a neighborhood like Taiwan's. So just some energy security thoughts to put on the table.

Gary, I'd like to sort of…let's get a little optimistic for a second.

DIRKS: Okay.

GROSS: Can we talk a little bit…we spoke earlier about sort of the idea of data centers being good citizens. And how can data centers work with the energy industry to at least start to solve some of their own problems?

DIRKS: Yeah. I think that's a really critical part of the solutions that we need to be thinking about going forward. And I would pull on three threads.

One is to begin with, like I mentioned earlier, the importance of social infrastructure to be able to deal in a joined-up way with the complexities. And that has to begin with transparency. One of the things that, that planners and people that are trying to respond to this demand would benefit enormously from is just a little bit better insight into what exactly is going to happen. I mentioned that we've got 40 gigawatts of demand in our queue. If a third of it actually, seriously in the end wants to be there, that'll be on the high side. So, pulling on that thread is a really important one.

The second thread that I think is important to be able to pull on is to recognize, and David mentioned this several times, all data centers are not equal. An AI training data center can actually be located out away from major metropolitan areas, where the fact that they are high latency, don't need to be responsive, is a gift to wherever you want to put them. Whereas the kinds of things that we want for inference, low latency, they need to be much closer in. So just having clarity about what is the purpose of this data center and being willing to put data centers that can run at high latency away from major metropolitan areas.

Then the third thing that can be done is, frankly, to be willing to be turned off. Because a lot of what we've talked about with respect to the grid's ability to respond, has to do with peak load and the fact that utility grids are really stressed for peak loads often. But if a data center is willing to be turned off, then, and often it's not for more than a couple of hours max, a few times a year when the local grid is most stressed, then there's more capacity, then there's more ability for the utility to say, yeah, it can get you power. Now, that is very much a band-aid. I don't want to propose that as the solution, because you still ultimately have to come up with the additional power. But right now, given the speed at which things are going, band-aids are probably going to be useful.

GROSS: Band-aids buy you time. And it seems like time is the absolute most important factor here. I talk to AI people, and they talk about time to power. So, there's something to be said for a band-aid–

EDELMAN: One point on that, which is, it's worth recognizing just how immature the science of machine learning is and how we are at this bottom of the first inning of this science. I mean, you know, there's a grad student at my lab at MIT five, six years ago, came up with a technique to do AI training slightly differently. Brought down the computational intensity of training that kind of AI model by 90%. Brilliant guy, grad student.

What it's illustrating is that we have necessarily not fully aligned ourselves -- I wrote a piece for Brookings that mentioned this a little while ago -- to the idea that the market incentives for AI right now, for the large foundation model companies are not necessarily strictly aligned towards reducing their power consumption. Which seems perverse when you first say it. Wait a minute, they want to lower their costs, don't they? Right. But also remember, this is an environment in which if there were two or three champions that emerged that had a very effective competitive moat, but convinced the rest of the world that you'd actually needed 5 gigawatts to train the next model, well then no one would go and do it. And so I think there's a very important opportunity that a lot of us, both in sort of the science of AI but also just in the politics and energy of it, recognize, which is, if governments are going to play a meaningful role in incentivizing science and pushing us, not just towards the optimism phase, which I am as well, but towards actually getting something for our optimism, it is investing in advancing the research of making these training runs more efficient.

I think we can get there. I think if you look at the cost, training costs going up, inference cost has absolutely cratered. You're able to do a hundred times more useful things per kilowatt in AI than you were a year and a half ago. So, there's a real opportunity, I think, here in science and in research to help address this lumbering reality of bringing new energy on the grid, which is slow.

GROSS: Well, this brings up two questions for me. One of them is, how can there not be an incentive to make the training process more efficient when power is the long pole in the tent right now in expanding AI? I mean, that's the thing that the system is lacking.

EDELMAN: There is, I don't want to pretend that these aren't real companies that really want to minimize their costs. At the same time, you have to recognize there's a short term or medium term and a long term. And the long term, a world in which they actually have to be accountable to, I don't know, public markets, that would actually be able to look at their balance sheet and be able to look at their liabilities, be able to look at, for instance, all the commitments they've made to infrastructure investments and the sort of circular universe that -- many of you have seen, that great Bloomberg graph about the AI economy -- that's a world in which this comes home to roost. The next 24 months, when there is a desire to

bring in as much private capital as possible -- and by the way, the private markets are almost tapped out, I would argue, in terms of what they're willing to concede and give to the foundation model companies -- and a desire to scare out competitors that would otherwise want to come in with perhaps wildly more computationally efficient models. Or -- and this is probably a more important direction with where the economy's headed -- narrower models that are more fit to purpose, that don't cost as much because they actually only operate in one knowledge domain. If I'm working in science, I don't actually need the AI model to write Shakespeare for me, as cute as that is. So, the idea that we're going to have different kinds of AI models are going to develop -- again, if the dominant narrative in the economy is you need a foundation model because it is performant across all domains -- that's very different than a world where smaller models, less load, and more opportunity for innovation. And so, I think that picture looks very different for any of these companies in the shorter and medium term than it does necessarily in the long term where they've already established themselves.

GROSS: Yeah, we're so focused on the large language models because that's how you and I and people here interact with AI. Well, this brings up another question, and Gary, I want to bring you in for a minute. What is the potential for AI to help fix this problem? I mean, you hear a lot and, and your thought about specialized AI really brings us back to here. Can we use AI to make the whole electricity system more efficient? Like when does this investment in power start to pay back?

DIRKS: Well, we absolutely can. And that is a very important thread of research that goes on in virtually any electrical engineering department. How can we apply AI to our own systems?

And I think as David was suggesting, there are real gains to be made in the way that the grid functions and is able to move power around. There's wonderful opportunities going forward. It's going to take a little bit of time, but it's wonderful opportunities for more transmission and especially HVDC and places that have grids that are not entirely synchronous.

I think there's a lot in the way that you can provide demand response. Because again, I mentioned it's often the peak that you're worried about. Good demand response programs that have the ability, for example, in our city to lower or raise air conditioning temperatures for a couple of hours, or an hour. Those things are all coming and those are all being driven by AI and many other examples you could give. So, yes.

Now the only thing I would caution is a lot of what we are talking about here is hitting us kind of right now, and three years matter. It's not going to be three years from now yet before they're going to be raising the temperature in half of the homes in Phoenix. That just isn't the timeline we're on. So, we should be looking forward to what it can do, but not expecting us to get us out of this moment.

GROSS: Fair enough. I mean, I think a lot of particularly environmentally oriented people I talk to sort of view AI as a black hole that power goes into, but you describe it as us being in the bottom of the first, in terms of what AI can do. And so, I'm hoping over time that we start to…these investments start to pay off, not just in terms of, you know, AI writing our papers for us in school, but in terms of actually making our economy and our industrial systems more efficient. So, we'll see. That's, I'm an optimist too. I have got to get up in the morning and that's kind of how I view it.

But Tarcy, I'd like to bring you in again on a, on a slightly less optimistic subject, unfortunately. But we've talked about this a little bit. Taiwan's in a rough neighborhood and definitely has some security issues, let's say. How is Taiwan approaching security of fuel

supply? We know there's fuel out there, but the key is it has to get into Taiwan so it can be used. How is Taiwan approaching energy security?

JHOU: Yeah, for energy security, we can divide it two parts. I would like to echo Gary's comments about AI, how according to our earlier official projection for the forecast, it's around 2.8% for annual growth rates in total electricity demand. But this year we announced the latest growth rate is already reduced to 1.7%. That's because we expect AI will not just push the electricity demand, but we [Taiwan] will also gain lots of energy efficiency from AI. This I think is the same idea, what Gary mentioned before.

And another thing is about what are we going to do to secure our energy security? First of all, we [Taiwan] already increased LNG energy storage, in the days [number of days] and also the capacity. And to increase their terminals to develop, it is undergoing. And for renewable energy acceleration, it's because we [Taiwan] would like to have more domestic energies because we are lacking in fossil fuel resources. So that's why we would like to develop renewable energy. That's another part.

Another thing is we also just increased the storage and the green modernizations. And the last part, just this year we [Taiwan] already had a referendum for nuclear power plants. But recently these past two months, we [Taiwan] already started to discuss if we [Taiwan] still have a need to have an extension for nuclear power plants or not. But it is still under discussion. But I will say in in the short term and the midterm, we [Taiwan] are going to rely on natural gas for around 50% of the total electricity generation, which means that there is still a big risk with our big neighbor, especially for shipping and importing natural gas.

GROSS: Well, to bring in another, a little bit of a sore subject is all of that natural gas is coming to Taiwan as LNG. So, you're exposed to some challenging LNG markets. I mean, we saw what happened in 2022 after Russia stopped delivering pipeline gas to Europe, Europe basically sucked in much of the world's LNG and raised prices for everyone. Is Taiwan prepared to deal with the costs of this strategy and how is that cost flowing through to consumers?

JHOU: The main buyer for LNG in Taiwan are state-owned companies. And so currently most of the costs are borne by those state-owned companies, like the petroleum company and also, for electricity, the cost is absorbed by the Taipower company. So that's why from the last year, we [Taiwan] already raised the electricity tariff because the Taipower company, they cannot bear this cost. And so, they would like to reflect the cost to the tariff, and then we [Taiwan] already raised the electricity tariff three times this year to reflect the fuel prices. This major problem…I will say that most people will abide by it, but the cost was largely paid by the state-owned company, the Taipower company.

GROSS: That…it's a really interesting question because you often hear that things that can't go on, won't. Politically, and this may be a sensitive question, tell me if you can't answer this, but this seems like an ongoing problem. The idea of needing to subsidize power, coming in with, you know, volatile LNG prices. How could that circle possibly be squared? What is -- I'm not expressing myself very well, but this just seems like a huge challenge to me.

JHOU: Previously the cost was borne by the Taipower company, but two years later, they say they would like to reflect them to the tariff. That's the reason. But so our [Taiwan's] plan is to try to secure more long-term contracts, for the LNG market it has fluctuated, but it's just the last two years. Right now, it is more flat and stable, and in the future we might see that the LNG price might be lower than today.

GROSS: Yeah, I don't think that's a terrible assumption. David.

EDELMAN: It is not just an LNG pinch though. I mean, we do have to recognize, I mean, right, right here, 20 miles from where we sit is the highest concentration of data centers probably, I think, in the world, certainly in the United States. I happen to live there. And it is an active discussion right now if whether or not Virginia in the United States will have to move to a two-tier tariff system where everybody else, certainly all the data centers, are paying one higher rate and consumers are paying a lower rate.

This is shocking from the standpoint of US energy policy. And yet this is very much the direction in which, right here, central to DC the conversation is possibly heading because the alternative is just saying no to the building of those data centers, which is also not an option if you look at the policy at the federal level.

So, this is the pinch that I think is not unique to Taiwan. It's uniquely exacerbated by the fuel mix in Taiwan. But it's one that I think we're going to have to reckon with across any country that is thinking about AI as national imperative, or God forbid, going toward the area of sovereign AI, which maybe we'll talk about, maybe we won't.

DIRKS: And if I could just add to that, the phrase in Arizona is growth pays for growth. And there's a very simple reason for it and is exactly what you just said, David. And that is the, the public is not going to subsidize, through their rate structures, investments in data centers. Period. And so, however it works out, all of the costs that includes the upfront capital costs as well as operations, any new transmission, all of it needs to go to the data center developers. Not a very popular suggestion in some quarters, but I don't think it's avoidable.

GROSS: No, I don't think it is either. And you hear the arguments that are happening here in Washington, not just in Taiwan. I mean, we live in the land of energy abundance. Taiwan is in a completely different situation, and yet we're both arguing about the impact of AI on affordability of electricity for consumers. I think that says a lot.

But, I mean, a question for you all is, I understand that electricity is the long pole in the tent for building new data centers, but on the other hand, it's not a big portion of their cost structure. Are they ready to bear the costs of building the new, I'm not sure they don't want to if you asked them, but is this the way?

DIRKS: Well, and again, in my experience, it's a bit of a mixed bag and, and the reality is actually some of the hyperscalers are sort of saying, yeah, maybe we are. You can see that in restarting some of the nuclear plants that electricity isn't necessarily going to be cheap, but yet –

GROSS: Not at all. And yet you see Microsoft restarting Three Mile Island.

DIRKS: Yeah, they're restarting it. There's even a lot of discussion now and not just in the United States, but certainly in the United States, about, well, let's just let them build and own it themselves.

GROSS: Behind the meter.

DIRKS: Sit behind the meter.

GROSS: Yeah.

DIRKS: Now there's a, that's a lot more complicated than what it sounds because you don't just build a power plant someplace and then, then it all works out fine. They've got all the same issues with building them the utility does, but what it is a signal is that they are willing to put more of this kind of cost on their balance sheets as opposed to seeing it land on utilities' balance sheets. So, I think there is room to maneuver there. It's early days and I would hesitate to say what model is exactly that's going to emerge, but yeah, you have to, you have to include that kind of thinking.

GROSS: Yeah. I mean, everybody's talking about AI. You can't turn around without hearing about it. But those costs have got to go somewhere and consumers are not anxious to bear them.

Okay. You mentioned sovereign AI, David, so I'm going to bite: what is it?

EDELMAN: So, we'll be doing a four-hour seminar right after this one on, yeah, what is it? What isn't it? What it primarily is, is a political slogan that allows countries outside the United States to try to demonstrate to their populace that they are on top of this AI thing. And then details, details, details, details beyond it. I think it means a lot of things to a lot of different governments. I think a lot of things to a lot of different people.

At the top line. I think the, the unifying concept is, well, one, there is anxiety about dependence on US large language model companies for the foundation models that are performing at the top level, at the, you know, top level of performance.

And second concern about the data centers and infrastructure, both for training, but even more for inference, being outside of the national borders. Now this is echoing with something that has actually been coming to us in the last decade. 20 years ago, requiring data sovereignty, data localization, requiring servers within your country, process, your internet data, was a non-tariff trade barrier. We had agreements that specified that this was not okay. And there were a lot of really good technical reasons for it because specifically the way, without going to too much detail, internet traffic works is, it doesn't care that much about national borders unless you create national borders for it. In fact, it's much more efficient for some of our data here on the East Coast of the US to be processed in places like Ireland than to go all the way west to California. That's just how the tubes work.

And so, there's this sort of latter-day reincarnation of the reconsideration of whether we actually need to have data localization. It's just taking on a new form. because everyone's talking about AI, it should be sovereign AI. Now look, there are very reasonable arguments for why you'd want to have this. Maybe you want to use this as a means to stimulate some of the production of data centers domestically. So, you say to the companies, you can't operate unless you build the data centers or to clarify minds to create a sort of more cohesive national energy or data center program to get, you know, folks up and down the government hierarchy aligned towards all the things we've been talking about. That all makes good sense. You know, I do think we also have to recognize though, that at the end of the day, sovereign AI is not just a slogan, it's actually a load forecast that comes with a bill, okay. If you're going to say sovereign AI, it means you are signing up for gigawatts, maybe terawatts, of new power generations going to go online, that you can't predict, that you are going to be accountable domestically if you are going to follow through on actually having AI as an important part of your economic productivity or development.

That to me, is a part of the bargain that most governments have not yet reckoned with and creates a real complication for this idea of politics riding above the technical realities.

Because there is a lot of efficiency to be had in putting data centers places, for instance, where it's cold and the heat doesn't matter all that much, where they can get energy that's not very costly.

And so you look even at like the EU and you know, there's a reason France and Mistral there, is able to sign this big deal with, I forget the exact number, 20,000 maybe Nvidia chips because they have 30 low carbon energy sites -- nuclear-- around the country that are ready to receive it. And so how does Belgium feel about that? Probably great, but this is a question that we're going to have to deal with country by country because the slogan is going to outpace specifically the energy need very quickly.

GROSS: Well, and this brings it back to what I think is the absolute central question of this panel. And that's what, what sovereign AI means for Taiwan and the thoughts of developing this very energy intensive technology in an area that is energy constrained in many ways, and that lives in a tough neighborhood in terms of energy security. How do you think about that? Because that's, I think that's like the fundamental reason why we're all sitting here. Any anybody want to say a few words about that? Or is, or is the question the point?

EDELMAN: Res ipsa? I mean, yes, it's a big problem out there. No, I mean, it is a problem that's particularly exacerbated by the energy mix in Taiwan. And so how do you deal with it in a really pragmatic way?

I'd say it's, it's probably a few things. One, it is having energy and technical reality meet the big picture, which is, it might not be the case that we are training hyper performant foundation models that lead the world in Taiwan. Maybe we will. And if there's the energy to do it, fantastic. And if there are technological breakthroughs that allow that to happen in a way that is more computationally efficient, smaller models, that's great.

I think there's even an opportunity, and I was just in Korea speaking about this you know, for certain countries in the region, certain jurisdictions in the region to actually double down on open source, publicly subsidized open-source AI models for particular applications. That's a direction that Taiwan could go.

But I think separating that and the idea of pride in national AI development from the idea of how do we make sure we can take a model, there are a lot of them, and run it with energy within our borders so that the economic productivity, which is immense, that can be unlocked even if AI progress were to stop today, that that can happen quickly and seize the cultural realities, that if you look at the surveys that are happening transpacific right now most Americans, large percentage don't really trust AI. It's actually a very high percent. A lot use it, but something like 70 plus percent don't trust it. Those trust numbers are actually vastly higher in parts of Asia, including in Taiwan. And so, an idea that you could actually have broader embrace at the inference level, having specific applications of AI that really matter, and then making sure there is the backstop of energy to run it, that's a way to thread this needle.

It might not feel like it's competitive with the US and AI development, but that's not the point.

GROSS: Fair enough. Does anyone…I'm getting ready to open it up to questions. So, think about your questions. And I'm just going to see if we want any final comments on that before I open it up.

DIRKS: Well, maybe let me build just a little bit on what David just said, because one of the conversations that goes on all the time is, well, what are the real benefits of having a data

center near you? And the conversation always begins with certain number of construction jobs. some tax revenues, and a few, not a lot, but a few permanent and decent jobs. And that tends to be where the conversation ends.

But what David is alluding to is really important. What is this going to enable? And do I want what it's going to enable in my backyard? And so, one of the conversations, for example, with us is, we have self-driving cars. Waymo is a, is getting to be a thing in Phoenix. Those things are enormously data hungry, and if you want them, then you have got have more low latency data centers to feed them. Arizona State University is pushing virtual reality like crazy, especially virtual reality in the classroom, and we've got good evidence to believe that it works very well. There's another low latency, really high data hungry application. How much of this is out there? Those, that's just two examples. What else is out there? And is it going to bring the kind of benefits where you say to yourself, alright, then I am going to have to find a way to get 500 megawatts to that place. And the water to support it and all the transmission that's required because we really do want it.

EDELMAN: And by the way, this isn't academic. Okay. Vehicle accidents are the single largest preventable cause of death in the United States. It averages somewhere between 38 and 41,000 Americans dead a year. That's just here. It's a million globally. So, you know, the numbers have actually come out, some really interesting number crunching just in the last few days on Waymo's early numbers. They're one of several players here. There's a public health spin on this that is actually worth considering because, you know, from where I said in government, if you told me we could unleash a technology that would start to tick away at preventing 38,000 preventable American deaths a year. That's like not hard.
And so that's just one of many evocative examples we can think about. Perhaps it's the most dramatic but there are others that we're going to start seeing more and more. Yes, there'll be productivity, but they'll also get to the core, I think, of what we think of government being supposed to be doing in this area, too.

GROSS: Yeah, I mean there it's a tough one. There are arguments before and against having the AI there. I would love to do a poll on trust in Waymo, but instead we are going to take some questions, so if you can bring the mic. I see you and you just across the aisle first. We'll come to you next. So can we take maybe two questions and we can kind of pool the answers.

AUDIENCE QUESTION, van Agtmael: Antoine van Agtmael, I actually have two quick questions. One is, we're all talking about AI and we're not really talking about nuclear fusion. But I wonder, can you, if you think five years ahead, can you actually do data centers in terms of their need of electricity without nuclear fusion? And can the development of nuclear fusion be speeded up?

Second question is, I think Deep Seek actually has shown that you can improve energy efficiency enormously if you use chips smarter. What are the lessons from that?

AUDIENCE QUESTION: Thank you. Yeah. I'm all in favor of Waymo, but Waymo is mostly local processing. It's not a heavy web user. Right. What I am concerned about the heavy web use, you mentioned the rapid adoption of ChatGPT. Most of the current use -- let me say I'm all in favor of the AI to solve particular problems, designing drugs, improving grid efficiency, a lot of things special models can do -- but so much of the use is frivolous, right? A lot. I just looked it up -- on AI -- that it's 800 times more energy intensive to have Gemini answer a query than the older Google queries. Right, it's cool that instead of having people in a classroom read a book about the Constitution convention, you can have a VR simulation and have people watch it. Much cooler, but much, much, much more energy intensive.

And so, my concern is why aren't we, you know, thinking or rating the uses, the frivolous use of high energy AI for chat companions, AI porn, high energy queries? You know, porn's always about 20, 30% of usage on new technologies. It's, you know, this is the only habitable planet in the known universe. We're risking it because the AI generation, instead of using all this great renewable energy to replace oil and gas, we're keeping the oil and gas because so much of the new energy is going to these AI uses? Can we prioritize?

GROSS: Who would like to begin?

DIRKS: Well, I'm willing to take a short cut at the fusion question.

EDELMAN: Oh, good. I was going to go there too. Go ahead.

GROSS: That's the easiest one for me too.

DIRKS: So again, I'm a techno optimist and there does appear to be some real progress being made on a number of different technologies. Both the inertial confinement as well as some of the, some of the magnetic confinements. And the company Helion is predicting that they're going to be on stream, supporting data centers before the end of this decade. Depending on what, what you read, '28, maybe, maybe a little bit longer out than that. I'm not that much of a techno optimist. I do think it's important that there's a lot of private money coming in, which is signaling that there's more and more optimism that this is ultimately going to work. But certainly everything I read suggests that there's still some pretty substantial hurdles to be overcome. So I would, if I were required to predict, I would say we're at least a decade out in spite of what other people are saying. And that might be overly optimistic too.

EDELMAN: Disclosure, I'm invested in this space and have been involved advising fusion companies for the last eight years. So, there is a general consensus across industry players, the lead players, the TAEs, CFS, Helion, Pacific, potentially in that space in these [off-mic] have raised over a billion dollars. Their timeline is end of decade or beginning of next decade. They pretty much all align on that. Do you believe them? A lot of that ultimately will come down to questions of capital availability. Questions of whether certain science risk can be retired. Uh-oh, am I dead here? Oh. Okay. [back on-mic] All right. Can we hear me? Oh, there we go. That's much better. Sorry. Whether certain science risk can be retired across certain configurations, and I think it's unlikely that you'd have five or six economically viable, scientifically proven out, fusion configurations that are pumping power onto the grid in the mid-2030s.

I think there probably will be a winnowing down of those potentials, but I, you know, Antoine, you, you raised a great question, and I think the answer in some level lies in the decisions that the hyperscalers are taking to invest in fusion companies. Helion's one of them, TAE's another, they've been working with Google and others. They have decided, after spending millions on their technical diligence, that either they think this is a great bet they're going to take a flyer on, or that they're going to need this kind of energy. And I think for all the conversation we've had today about the need for firm baseload energy and some of the trade-offs of conventional nuclear fission, there's a reason why fusion is not just a hope and dream, but actually an area they're putting their dollars into. So, that's the first one.

On the second question which it's, it's hard to disagree with, right? Yes, does it make sense to go ask ChatGPT what's the weather in Arlington, Virginia today? No, you could save a lot of energy by just Googling that. I will say this is, I do spend a bit of my time working with

companies on how they're thinking about what AI they're going to adopt within the company. And right now, where the rubber hits the road on that is, a company that is providing an internal chat bot, okay? So, it could be ChatGPT, it could be Claude, it could be their own thing. They actually have to make the decision of what they're willing to spend on API costs because they actually have to pay, unlike Google, they have to pay -- unlike Google search -- they have to pay for, okay, it's going to go out to ChatGPT and that just costs you three quarters of a cent to ask that question. A lot more if you start to give it two 500-page PDFs and say, summarize these for me.

And so, while, yes, at the macro level, I think a lot of us think about this as consumers that have an all you can eat plan right now. I don't know, it reminds me of very early days of electricity when you didn't pay for meter either. All you can eat plan. Soon, those of us that are dealing at the enterprise level and the companies that are using this at large scale are dealing at the API level. They actually have to pay per inference. They have to pay for a useful thing. And that might cause the economics of some of this to level out. It also might cause a world which, and I think you're describing, there is a greater attention both on the user side and on the design side to what these systems are built to do. If you're looking at what real companies are using AI for. They don't want most of their people going out and using it for writing poems to whatever. That's not the use case they envisage. And so, the idea that you would actually have an atomization of AI portals, so to speak, tools that you're using and greater consumer awareness of what the right one fit for purpose is, that strikes me as reasonable. And I think the question that you raise, which no one has an answer to, at least I don't, is, okay, and now how can governments and industry incentivize that before it's just a question of dollars, and I think that's a question of policy.

GROSS: Yeah, and I'll bite for just a quick second on the moral question. It's a really tough one and it's easy with a new technology to say this is frivolous. And I think we've done it with every new technology in the history of ever. Said, you know, this is frivolous, we shouldn't spend energy doing this. But I mean, it is tough to win that moral argument. I work on climate change issues now for a really long time. That's a moral argument that's tough to win too. I think rather than sort of fighting it on morality, which is often honestly a losing fight, the best way to go about it is pricing in what it actually costs, and then also working really hard to make the whole system more efficient. So, the moral question becomes a bit less salient.

I mean, that's what we're doing in the electricity space. We are, rather than pounding on people to use less electricity, charge what it really costs and try to make renewable electricity cheaper. And so, I think it's a pretty fair comparison. Let's get a couple more questions. Can we get you and Shirley, do you want to come in?

AUDIENCE QUESTION, McCrae: Hello there, Chris McCrae. I've been working with scaling branding all my life and I have three main conflicts now and I was wondering if you could help me with them. Firstly, because I work mainly in Asia, the three places I want to see continue freely are Taiwan, Hong Kong, and Singapore. Simply, because I've just learned an awful lot from people in those places.

GROSS: Nice places.

AUDIENCE QUESTION, McCrae: The second thing is the subjects you've been talking about, like, energy, AI, connection with science. It seems to me that the edge of those is changing every three months. So how do we get students to be ahead rather than behind? Because, you know, if you are on a four-year course, what is that? Your, you know, you're 1/12th in the game? But the third question is over the next six months in DC, where would you send students conferences like maybe SCSP [Special Competitive Studies Project], .AI,

or SMID, or just to mention, because I'm not sure, have you all heard of genesis.energy.gov? It's absolutely in the middle of all the topics that you've been discussing. But I only got it in my email box two days ago. It's basically the Department of Energy's idea of how to use energy, AI, and science in positive ways. And it's the first nine months of their conclusion on that is at that website.

AUDIENCE QUESTION, LIN: Thanks. So, similarly for Asia-Pacific I wanted to ask Tarcy and Gary, is Taiwan's challenge singular or is it very similar to its neighbors, mainly Japan and South Korea, in terms of this trilemma, the environment, energy, and economic growth. Thank you.

JHOU: Yeah. Hi. Can you hear me? Yes. So, in the APEC region, actually Taiwan's challenge is not singular in facing AI. Some countries like Singapore and Malaysia, they are striving to be hubs for data centers. And these two countries already have a different view on AI and their electricity demands, and they are already considering about how to manage this part.

For example, in Malaysia, their policy already emphasizes near chain for reliability. But another thing is they are also concerned with how much money they can earn from this part, if they would like to pay a lot of money on infrastructure and also to pay a lot of the costs for the electricity consumption. And so they would like to evaluate in these supply chains.

And then Singapore is another case. Singapore in the future might also be an AI hub in Asia. And for Singapore, this provides some constraints on the demand side, management. But these past two years, they have already started to consider just how to manage this problem.

So, Taiwan is not the only one who faces this problem. Because infrastructure needs to be built very fast. However, the time [rate of infrastructure development and energy need] is not match. This is a regional problem. It's not just for Taiwan. And also, Korea and Japan also have the same problem. But luckily Japan and Korea already have nuclear power plants. So the situation might be a little bit different because they have more of a base load for the electricity [demand]. So the energy situation, this part is different from Taiwan. And also [differs from] Malaysia, because they have fossil fuel reserves. This part, they [Malaysia, Japan, Korea] can secure their energy security. So this comparatives within the APEC regions.

DIRKS: I'll maybe pick up on the question about students, because I think Tarcy has covered your question very well. There's sort of three things that I would point to that we try to do. Beginning with the mindset that you're learning in real time. Things are changing so fast that a professor really shouldn't suggest that I'm materially ahead of you in terms of where the leading edge actually is. And so the three things that you really need to pull on are first, give them a foundation really, really fast in what the fundamentals of these systems are. And one of the things I talk about a lot is, if you don't know the difference between a volt and a watt, or a megawatt and a megawatt hour. Let's start there, and kind of fill that gap in so you kind of get a sense of what that is. And then on the AI side, latency is a really good place to understand that there are different kinds of data centers. So start there.

Then the second to really work on is how do you go about teaching yourself? Where do you go to get high quality information? And you mentioned that there isn't one place to send them. There's a lot of places, including good places for data and background, including the Brookings Institution, by the way. And how do you learn yourself. Often, frankly,

accompanied by your favorite AI tool to help you synthesize all of this stuff and think about it, recognizing that AI makes mistakes.

And then third is a very active program of seminars. Constantly seminar, seminar, seminar, seminar on some subject where you can involve the students in it, both from the standpoint of participating but listening because you really are doing it, like I said, in real time.

GROSS: David, we have just a minute or so, but any wrap up comments or answers to those questions?

EDELMAN: Well, I think my, my colleagues answered them very well. Except for, I'll just take a moment and recognize that the most useful thing that AI has been able to do has only been around now for about a year and a month. Right. Real agentic Claude Coding and examples of that. This tool's been around for three years. Three years. Okay. So, where do I direct people to go? I direct them back to their computers to go spend time with it and to actually build applications with it and to do it. I was talking to somebody yesterday who runs a very large IT enterprise. It's a very seasoned professional, 25 years in the industry. He confided in me, he said, I just feel like I have no idea what's going on here. None of my people use this. I'm afraid of it, and I just have lots of pressure. What do I do? And I think the answer to the message, to all us on some level, is actually learning it is using it. And as we just heard, learn the fundamentals about what the implications of it are, what goes into it, what it means for all of us.

And I guess I'd close that on this. Taiwan's energy and AI challenges, as we've seen in five points here are a microcosm of what's happening in the broader world. I mean, it is happening in, as so often happens in the region, a more dramatic way, a more pronounced way, a more security tenuous way in Taiwan. But I think we have to recognize that this is an opportunity that we all have to address these issues together. And you know, more comprehensively, that when it comes to AI competition, grid and science policy are your strategy and everything else is just talk.

And so the question now is, can we all, Taiwan, but also on this side of the Pacific as well, get serious about what that means and start to share the science and the technological advancements that can make this particular advancement of AI not cost oh so very much as Shirley said, across our broader economies, our environments, and beyond.

GROSS: Yeah. Well, I'm sad to say that we're out of time because this has been fascinating. We've spent a lot of this time talking about the inputs into AI and the challenges of the inputs into AI. And they're really similar across an energy abundant place like here in the United States, or an energy constrained place like Taiwan, or much of the Asia-Pacific region. But I think the optimistic thought to leave the room with today is thinking about the outputs and what you've described and the things that we can do with it. And I love your analogy that we're only in the bottom of the first inning. I'm only beginning to use AI myself, and I'm fascinated by what this can do for me and how much productivity it can bring to me. And I'm literally brand new to the space. And so let's hope that the outputs are well worth the inputs.

And I'd like to thank my speakers – everyone else who's been involved with this. This has just been a fascinating event. So, thanks to you all and I'm glad you could join us.