Center for International
Trade and Security
School of Public & International Affairs
UNIVERSITY OF GEORGIA

UGA CITS 2022
Energy Security Conference

Challenges and Opportunities in a Lower Carbon Future

Beneath every concern about climate security and economic security lurks a more fundamental concern: energy security. The conversation hosted by the Center for International Trade and Security (CITS) on April 28, 2022 at the University of Georgia put a much needed spotlight on pressing energy issues. The distinguished experts in the room agreed that the world can no longer afford to ignore the uncomfortable realties of global energy demand. Lofty goals set by the international community will be meaningless if we cannot provide reliable, baseload power to our populations.

Much of the world appears to be realizing this. From Southeast Asia to North America, countries everywhere are rethinking what it means to be "energy secure." And nowhere is this more evident than in the nations of Central and Eastern Europe. Our conference, which had been planned for over two years, took place just two months after Russia invaded Ukraine. This single event sharpened the continent's (and the world's) focus on energy security issues, and it loomed large during our day-long discussion. Our panelists and our wonderful audience members pondered these recent developments, but they also tackled the longer term strategic and tactical steps needed to put our country and our world back on the path towards true energy security.

We are grateful to the experts who traveled from around the United States and Europe to share their insights with us. They joined us from industry, academia, and the public sector, providing diverse perspectives on the challenges and opportunities of the coming decades. They also helped us to make sense of a global energy trade that has been thrown into utter chaos. And while they shared some pessimism, they also offered glimmers of hope. We are also very grateful to our sponsors and partners who helped make the conference happen, including the UGA Provost's Office.

The Energy Security Conference was one of many important forums hosted by CITS this year. In January, we also hosted our inaugural Energy Outlook in cooperation with the UGA College of Engineering. And in August, we hosted the Nuclear Energy Summit featuring delegates from the U.S., Canada, Japan and Korea. Throughout the year, we learned that like-minded countries around the world are recognizing that energy scarcity poses an immediate threat. Luckily, these countries also have the capabilities to correct decades of short-sighted energy policies. We look forward to tackling these issues together.

Thank you,

Justin Conrad

Gary K. Bertsch Director of the Center for International Trade and Security
Associate Professor of International Affairs
University of Georgia

UGA CITS 2022 Energy Security Conference

Challenges and Opportunities in a Lower Carbon Future

AGENDA

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Dr. David Gattie, College of Engineering/CITS
Dean Matthew Auer, School of Public and International Affairs
Dean Donald Leo, College of Engineering

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RDML (ret.) Michael Hewitt, IP3
Dr. Tomas Janeliunas, Vilnius University
Dr. Justin Conrad, University of Georgia

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Dr. Valerie Thomas, Georgia Institute of Technology
John Harju, University of North Dakota
Dr. Richard Axelbaum, Washington University in St. Louis

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1:30 PM – 3:00 PM

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Jeff Grubb, Georgia Power
Laura Schepis, Jacksonville Electric Authority
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3:30 PM – 5:00 PM

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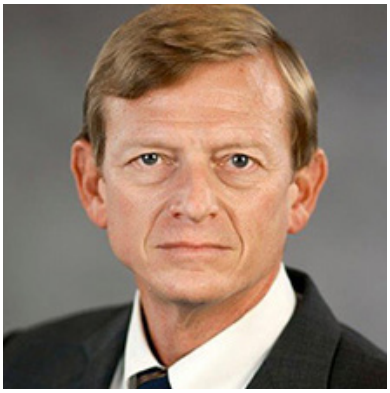
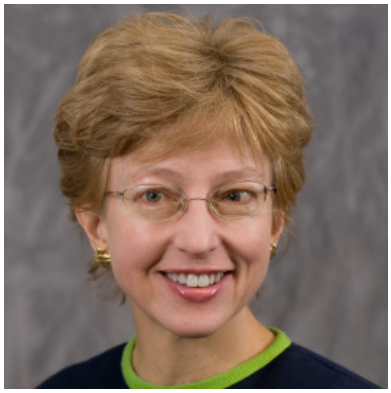
Rob Sweeney, nXSolutions
Will Cook, QED Analytics
Dr. Gopi Munisamy, University of Georgia



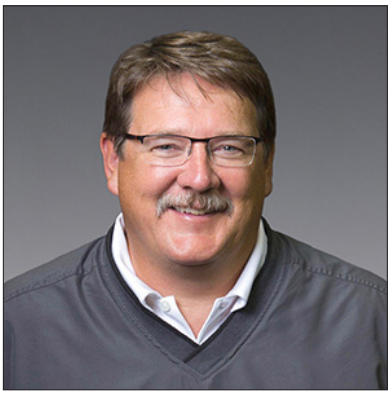
Rear Admiral Michael Hewitt is co-founder and CEO of IP3 (International Peace, Power, and Prosperity), an international energy and security company with the mission of bringing safe and secure nuclear power to the world's most critical markets. RDML Hewitt retired from active duty after 31 years of service in the United States Navy with experience in a wide variety of areas including naval aviation, acquisition programs, legislative affairs, joint warfare, information operations, cyberspace operations, and non-kinetic and net warfare. After retiring, RDML Hewitt founded HSH Analytics, a company dedicated to providing unmatched expertise in special access program operational employment, future warfighting scenario development and emerging technologies aligned to asymmetric warfare.

Dr. Tomas Janeliūnas is a full-time professor at the Institute of International Relations and Political Science (IIRPS), Vilnius University, since 2015. He has been lecturing at the IIRPS since 2003 on subjects including Strategic Studies, National Security, and Foreign Policy of Lithuania, as well as Foreign Policy of the Great Powers. He has served as the head of the Department of International Relations at the IIRPS, as Editor-in-Chief of the main Lithuanian academic quarterly of political science, *Politologija*, and served as the Editor-in-Chief of *Lithuanian Foreign Policy Review.* His latest book, *Foreign Policy Analysis of a Baltic State: Lithuania and 'Grybauskaitė Doctrine'* (London: Routledge, 2021), focuses on the conduct of Lithuanian foreign policy during the two consecutive terms of President Dalia Grybauskaitė in 2009–19.

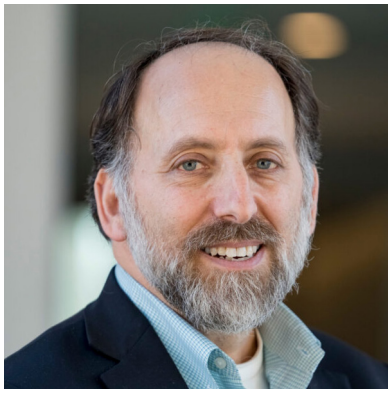
Dr. Justin Conrad is the Gary K. Bertsch Director of the Center for International Trade and Security and Associate Professor of International Affairs. He studies international security issues, including nuclear proliferation, interstate conflict, and terrorism. Dr. Conrad's work has been funded by civil, defense, and philanthropic organizations, and his research has been published in leading academic journals. He is the author of two books, *Gambling and War* and *Militant Competition*. Dr. Conrad has appeared in a variety of international media outlets. He is also a key researcher at the Resources and Conflict Project. In addition to his research activities, Dr. Conrad develops and implements training programs for government officials and corporate audiences on topics such as counterproliferation and strategic trade management. He is also a former U.S. Navy officer and has worked in the international private sector.



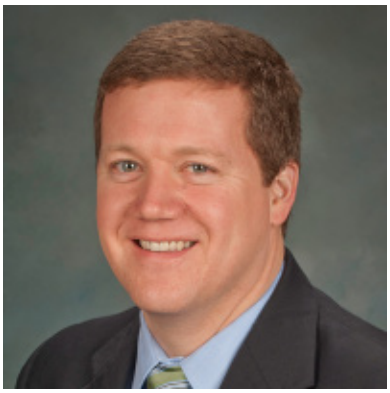
Dr. Valerie Thomas is the Anderson–Interface Chair of Natural Systems and Professor in the H. Milton School of Industrial and Systems Engineering, with a joint appointment in the School of Public Policy. Dr. Thomas's research interests are energy and materials efficiency, sustainability, industrial ecology, technology assessment, international security, and science and technology policy. Current research projects include the environmental impacts of biofuels, and electricity system development. Dr. Thomas serves on the DOE/USDA Biomass Research and Development Technical Advisory Committee. From 2004 to 2005, she was the American Physical Society Congressional Science Fellow. Dr. Thomas was a Member of the U.S. EPA Science Advisory Board from 2003 to 2009. She is a fellow of the American Association for the Advancement of Science and of the American Physical Society.



John Harju is Vice President for Strategic Partnerships at the Energy & Environmental Research Center (EERC), where he leads efforts to build and grow dynamic partnerships with industry, government, and research entities in support of the EERC's mission to provide practical, pioneering solutions to the world's energy and environmental challenges. He was appointed by the U.S. Secretary of Energy to serve on the National Coal Council in 2018 and was appointed to the National Petroleum Council in 2010. He also served on the U.S. Department of Energy's Unconventional Resources Technology Advisory Committee (URTAC) from 2012 to 2014. Mr. Harju was appointed to the Interstate Oil and Gas Compact Commission (IOGCC) in 2010, serving on the Energy Resources, Research, and Technology Committee and on IOGCC's Carbon Capture and Geological Storage Task Force.

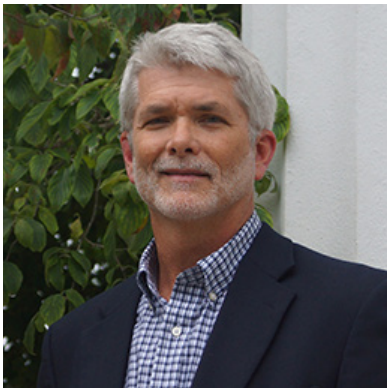


Dr. Richard Axelbaum holds the position of the Jens Professor of Environmental Engineering Science in the Department of Energy, Environmental, and Chemical Engineering at Washington University in St. Louis. Since 2009, he has been the Director of the Consortium for Clean Coal Utilization at WashU, which has received over $25M in research support from government and industry. From 1998 to 2007, he was chairman and chief scientific advisor for AP Materials, Inc., a startup company he founded that specialized in flame synthesis of energy storage materials. Cabot Corporation acquired the company in August 2007. Dr. Axelbaum is leading the development of the staged pressurized oxy-combustion (SPOC) process, which is one of the leading carbon-capture technologies for coal plants. He has over 130 peer-reviewed publications and holds five patents.



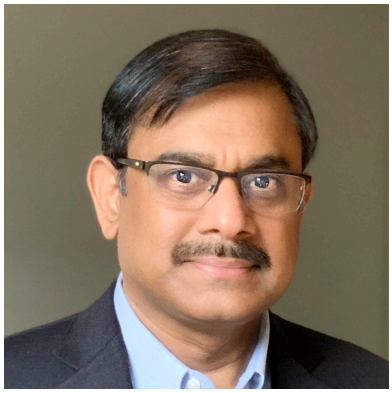
Jeff Grubb is the Director of Resource Policy & Planning at Georgia Power Company where he leads the team responsible for long-term generation planning including the development of the company's Integrated Resource Plan (IRP). Georgia's IRP is filed with the Georgia Public Service Commission every three years with the latest just having been completed in January 2022. Jeff serves as the lead public witness in those proceedings. Jeff also served as a Project Manager in Resource Planning at Southern Company Services (SCS). In that role he managed the development and coordination of the system-wide integrated resource plan for the retail operating companies of Southern Company, as well as economic evaluations for special projects. He also provided regulatory support to the operating companies and was involved in many planning coordination activities across the system.

Laura Schepis has more than 15 years of experience in the government affairs and communications industries in Washington D.C., Virginia, and Tennessee. In her role at Jacksonville Electric Authority she oversees JEA's government affairs, media relations, communications, environmental operations, and compliance monitoring departments. For the past three years, Schepis was senior director of National Security Policy for Edison Electric Institute in Washington D.C. Her responsibilities included leveraging electric utility and government partnerships to enhance preparing for and defending against significant natural disasters and attacks on the energy grid.

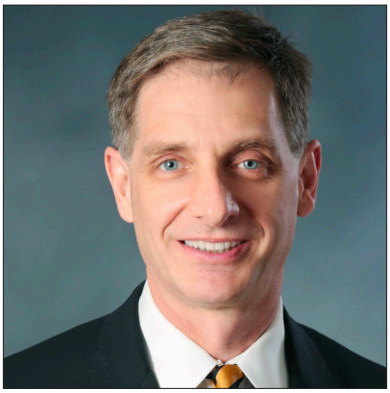


Dr. David Gattie is an Associate Professor of Engineering in the University of Georgia's College of Engineering (CENGR), School of Environmental, Civil, Agricultural and Mechanical Engineering, and a Senior Fellow in the University of Georgia's Center for International Trade and Security. He has 14 years of private industry experience as an energy services engineer and environmental engineer. His research is in the area of energy policy and integrated energy resource planning for the power sector with a particular focus on the national security implications of U.S. nuclear power. Dr. Gattie teaches graduate and undergraduate courses in energy systems and energy security for both the College of Engineering and the Center for International Trade and Security. He also serves on the Advisory Board for the Energy Policy Institute at Boise State University and on the Advocacy Council for Nuclear Matters. He also has provided testimony before the U.S. House Energy and Commerce Committee

Robert (Rob) Sweeney is an experienced executive, engineer, and entrepreneur working in the energy and infrastructure industry for over 35 years with leading companies and major project expertise. During his career, he was involved in a number of nuclear projects, successful turnarounds, and setting of industry benchmarks. He is currently serving a second term on the Civil Nuclear Trade Advisory Committee. Mr. Sweeney is also a member of the U.S. International Trade Administration's Small Modular Reactor Public-Private Program initiative and is involved in Nuclear Energy Institute's task forces on advanced reactor and construction focused on deployments and reducing risks. Mr. Sweeney currently advises the world's third largest nuclear utility on executive level matters, as well as other U.S. companies. He currently is Head of Energy & Infrastructure at nXSolutions, involved in private project development and financing on a number of overseas energy projects, as well as two early-stage domestic nuclear projects.



Dr. Gopi Munisamy is a Distinguished Professor of Agricultural Marketing. His research areas include International Trade and Investment, Agricultural Policy, Productivity, Economic Development, and Consumer Demand. He has served as Chair of the Global Forum on Agriculture for the OECD, Chair of the International Section of the Agricultural and Applied Economics Association, and Chair of the International Agricultural Trade Research Consortium.



Will Cook is co-founder and CFO of QED Analytics, a privately held defense contractor that specializes in engineering, acquisition, business operations, and research in the social sciences. He has more than 20 years' experience in manufacturing, operations, financial management, and data analytics. In addition to his corporate roles at QED, Will directly supports clients by conducting industrial base and supply chain risk analysis for U.S. Department of Defense (DOD) programs. He has been instrumental in developing a suite of analysis tools that captures data from external sources to identify industrial base vulnerabilities for a DOD agency. Most recently, he supported DOD efforts to identify risks during the COVID pandemic and the Russian–Ukrainian conflict.

PANEL ONE

Energy and Geopolitics

Left to Right: Dr. Justin Conrad, Dr. Valerie Thomas, Jeff Grubb, Laura Schepis, Dr. David Gattie, Rob Sweeney, Rear Admiral Mike Hewitt, Will Cook, Dr. Gopi Munisamy, Dr. Richard Axelbaum

Dr. David Gattie: Good morning, and welcome to what we hope to be the first of many annual University of Georgia energy security conferences. My name is David Gattie. I'm an associate professor here at the University of Georgia College of Engineering and a senior fellow with the Center for International Trade and Security. Just a little bit of background on what today is about and how it came to be: we actually had planned this a couple of years ago back in 2020, but then COVID stepped in and shifted gears and changed all of our plans. As it turns out, it worked out well, we think, with the timing of what we're seeing right now around the world, particularly over in Eastern Europe, with the Russia–Ukraine issues. The things that we've been working on between Engineering and SPIA, with CITS have all been focused on the security issues of energy, we really are trying to elevate that conversation to the level of energy security, national security, economic security, and climate security. So, the past two years have actually allowed us some time to think these things through a lot more deeply than we probably were hired to do a couple of years ago. So, we're excited about being able to have it while the circumstances are not preferable in Eastern Europe, nonetheless, they hopefully are serving as kind of a shot over the bow for how critical looking at energy as a security issue should be. We are privileged to have some very good, excellent speakers from around the world. We've got some, again, we've got a visitor here from Lithuania, who will be on our first panel. But we have identified some folks across the country who are like-minded here as far as seeing this issue for the security level issue that it is and we're excited to hear from them. The format for the day, we're going to record this and compile it as a transcript, we'll send it back out to the panelists to make sure it meets their approval, but we're going to compile this and make it available publicly. So take notes or whatever you want to do. But eventually this will be made public so everybody will have a chance to review it. And again, we're looking forward to this. We're trying to build relationships here today. We are trying to start this thing that we hope the University of Georgia will be able to sustain over the coming years. I do want to identify—I just noticed you stepped in with this bow tie here. We've got a Public Service Commissioner, who will have a few comments later on maybe around panel three or something. But I'm glad you were able to make it Commissioner Tim Echols. Thank you for being here. Commissioner Echols is one of our esteemed members of the State of Georgia's pragmatic thinking on energy issues. And we appreciate you being here, Commissioner Echols. Thank you. So what I want to do first is we have a couple of comments here that we want to have from our Dean from the School of Public and International Affairs Dean Auer was not able to be with us. He is in D.C. today. And then following that up with the Dean of the College of Engineering, Dean Leo. So, we've got Dean Auer on video, he'll speak to us here, give a greeting and then Don if you'll come up right after that.

Dean Matt Auer: Hi, I'm Matt Auer, our Dean of the School of Public and International Affairs at the University of Georgia. I'm delighted to welcome you to the 2022 Energy Security Conference hosted by the Center for International Trade and Security, or CITS. Of course, there are many vantage points on the subject of energy. At CITS, the organizing framework is that energy is fundamentally a security issue. To illustrate, every day, the nation's complex power transmission grid is tested by bad actors looking for a way in. Across the Atlantic, we're seeing in real time, the energy and security of nations that rely on energy from an unreliable or hostile neighboring state. And the repercussions are felt here too. And as we know, if the planet depends on carbon intensive fuels, the planet is environmentally insecure. Participants in today's conference know these risks well, and they also know how to tackle them. We're so fortunate

to be able to bring together leading experts from industry in the technology sector, utility regulators, academics, and others to present the challenges of creating a low carbon future. We also know our panelists can combine their knowledge and experience to move us well along the path to a zero emissions future. I want to thank Justin Conrad, the Gary K. Bertsch Director of the Center for International Trade and Security and his team. And also thank the College of Engineering. And a special thank you to the Provost State of the Art Conference initiative for supporting this important gathering. I hope all panel participants and audience members will benefit from today's proceedings.

Dean Don Leo: Good morning, everyone. As David mentioned, my name is Don Leo, I have the honor of serving as the Dean of our College of Engineering here and I just want to add my welcome on behalf of the college. And also follow on some of the comments that Dean Auer mentioned a minute ago. You know, just real quickly about our college. We are a relatively young college here at the University of Georgia, maybe you know that the University of Georgia is over 230 years old. We're the first state chartered public institution in the United States, but our engineering college was only formed about 10 years ago. And I'm excited to see that we've grown now to about 2,600 students, close to 100 faculty probably after this hiring cycle, and 50 or so staff and it's exciting to see Dr. Gattie here. I see Dr. Fouts in the back and some of our students as well. So it's exciting that we're part of this initiative. You know, I'll just reinforce a couple points. One, that's incredibly obvious. You know, I've turned on my smartphone this morning, the CNN feed said Russian gas prices, right Russian gas. So to reinforce what David and Matt said, you know, obviously, this is an incredibly timely meeting, I'm not sure how the organizers manipulated world events to make it even more timely. But you know, obviously, with what we're seeing with climate change, environmental action, and everything that's going on in Ukraine and elsewhere, obviously, I just want to commend the committee for putting together a great agenda today. And I know that it'll be a very productive meeting. My only other point really is also maybe to add to what Matt said a minute ago, you know, I really think this is exactly what our university and you know this meeting should be about, you know, our university is a public land grant university research intensive university here in the state of Georgia. What I'm really excited about as an engineering Dean and university like UGA is that we have David, Tim, other faculty in our college, connecting with the School of Public and International Affairs and others across campus to really address these global challenges. Because I think our perspective here, both in our college and across the university, is that these challenges aren't necessarily just technical challenges, right? They're not engineering challenges. They're not just policy challenges, you know, we really need to bring together the best minds from engineering, public policy, law, business, and I think UGA does that very well. And I think this meeting is a great example so I just want to add to Matt's comments, and commend Justin and all the other, you know, organizing members, David, thanks for your leadership on this topic. And I know you'll be speaking about that later in the meeting. And I just want to say on behalf of the college, have a great meeting and looking forward to the next steps in the initiative. Thanks.

Gattie: And with that, I'm going to ask the first panel if they would come up. We'll introduce them as they move forward. That chair over there on the end, it's mine, I'm moderating. Don't sit in that chair over there. What we'll do, they'll—each speaker will come up with about maybe 10 minutes or less of comments. Then we'll follow that up in probably about 40 minutes of panel discussion and questions that I'll lead, and then we'll go to the floor for questions from the

floor after that. So who we have with us and this will start from my left and move in this direction. This is a personal admiration society as far as I'm concerned, particularly, as the folks we have up here but Admiral Mike Hewitt, who is not only someone I admired immensely, but he's a friend. He's somebody who, you know, his background is Navy, Rear Admiral, retired co-founder and CEO of IP3, International Peace, Power and Prosperity. It's an international energy and security company with the mission of bringing safe and secure nuclear power to the world's most critical markets. Admiral Hewitt retired from active duty after 31 years. Mike and I have been communicating for probably about the past five or six years. He has a wealth of knowledge. He is well-traveled, understands this topic inside and out. Really excited about Mike being here and hearing his comments and discussion. From Lithuania, we have Dr. Tomas Janeliūnas. He's a full-time professor at the Institute of International Relations and political science, in Vilnius—Tomas—Vilnius University since 2015. He's been lecturing at IIRPS since '03 on subjects around strategic studies, national security, foreign policy of Lithuania, as well as foreign policy of great powers. Mike and Tomas, I'm sure could probably spend two days—Mike spent a great deal of time over in Eastern Europe. I accused him this morning of conducting shuttle diplomacy over the past six months, but he and Tomas have probably more to talk about than we can shake a stick at. And I'm looking forward to hearing them do that. And then of course, my colleague and friend, Dr. Justin Conrad. He is the Gary K. Bertsch—Is Gary in here? Gary. Gary, would you stand up? I'm going to let Justin—Gary is the namesake for Justin's position here. In fact, if not for Gary then Justin wouldn't have a job. And I wouldn't be talking about energy security. And none of y'all would be in this room. We're thankful for you. Appreciate you. He's Justin, Gary K. Bertsch Director of the Center for International Trade and Security. He's an associate professor of international affairs. He studies international security issues, nuclear proliferation, interstate conflict, and terrorism. His work has been funded by civil defense and philanthropic organizations. And he's published of course in leading journals. He's also the author of two books, one *Militant Competition*, and my favorite *Gambling and War*. It's got a picture of what the king of clubs on that thing—yeah a king of clubs on the book. So what I'll do is I'm going to turn over first to Admiral Hewitt, Mike Hewitt and my friend from D.C. And I'll let him get started. And then we'll move right down the line with Tomas, and then to Justin. Okay.

Rear Admiral Mike Hewitt: Good morning, everybody. And thanks for having me. Let me start by congratulating the University of Georgia, for putting this together. Something that David and I have talked about for the last four or five years, is how do we reframe this conversation of energy security, energy sovereignty, how we understood the linkage between energy and foreign policy and national security, but we felt as though the conversation had gotten off track and there really wasn't anybody that was framing it, the way that we're going to frame it today. And so David and I have been great friends for a number of years. I will brag that David has informed most of the key thinkers in Washington D.C., over the last two years with his writing, with his ability to help us communicate key issues to key leaders in Washington and abroad. And so not only are we great friends, I have leveraged his thinking on national security and energy, probably more so than anyone and I had the fortunate opportunity to convey many of David's thoughts to people that are speaking to the president, speaking to Congress, speaking to world leaders. And so what you're doing here today, timing notwithstanding, is something that I think we're going to repeat and build upon. And I think the sky's the limit for the University of Georgia and what you're about to put together. So David, and Justin and the entire School

of International Affairs and Engineering, congratulations, for putting this together. You're at the inaugural event of many, many more. So thank you for inviting me. I could not be prouder to be here. As David mentioned, I've been over in Europe for the better part of the last two years, because that's where this entire conversation is playing out on the world stage. We as a company formed in 2016, because we were concerned about the proliferation risk of nuclear power in the hands of Russia and China, in an industry that we saw was critical not just for climate change, but for energy security and energy sovereignty. And the world was moving into nuclear power very aggressively, without the United States being actively involved. We were very concerned about that. So we formed a company that said, the best proliferation strategy is one of massive civilian nuclear power construction, led by the United States to the highest standard of security and care that our country created alongside our allies, particularly UK. So we formed a company to help US companies compete against Russia and China in the state owned enterprises of nuclear power. Recognizing that nuclear power is a critical element of climate change, although we had kind of gotten out of that conversation here in this country. So one of the things that David and I have talked a lot about is energy sovereignty. And it's slightly different from energy security. And so every country in Europe right now is talking about energy sovereignty. So I was in Bulgaria, less than a month ago, working on this exact program. I was in Warsaw the night before the invasion by Russia into Ukraine, and the Poles who have been leading as you know, the refugee effort, and supporting the Ukrainians, they said to me that night, there'll be 3 million Ukrainians coming across the border in the next 30 days. So we see a lot through the European nations of what's playing out in this Energy and Security conversation there. How does climate change impact this conversation? And I think, unfortunately, in our country and in Europe, and in the EU, and in Germany, we allowed climate policy to drive energy policy, which then drove foreign policy. And what we're seeing now is a reversal. Because we over committed to a decarbonization strategy that didn't take account for the other two elements, which are abundant power, and baseload power, which are needed in these countries. So we keep it simple in the military, I just call it the ABC, you have to have abundant power, baseload power and clean power. And you can't trade one for the other, you must think about all three. Unfortunately, in our country, coming out of the Paris Climate Accord, we really focused on climate policy and decarbonization policy, which are critically important, but they can't drive the abundant and baseload argument by themselves. So what you're seeing in the world today is a population growth from seven to 10 billion people, over a billion have no power today, another 2 billion of that seven, really have inadequate power for industrialization. So you think about that as a premise to this conversation. And then you say, well, I will just prefer you to decarbonize instead of industrialize. And many of these countries just simply can't do that. And the Russians, and the Chinese have long figured out that energy is the currency of the 21st century. And so we have to kind of retrieve this conversation, and be equally a part of it in our country. And so I went over to the UK two years ago, because it was the center of gravity of this conversation. The UK had a bunch of nuclear power, that was the end of their fatigue life, they don't have the natural gas that we had in this country, they really weren't energy independent. And they really oversubscribed to offshore wind. And so all of these things manifested themselves together into the energy crisis that they're seeing right now. And this was not a crisis caused by Putin. This was a crisis caused by not having enough abundant baseload power for the demands of your citizens. And so simply put, the energy crisis in this spike in energy was caused by an over reliance on intermittent sources of energy, and getting away from fossil fuels prematurely. So all of this is a big

wake up call in Europe right now. And my work in Poland and Bulgaria, and even in Ukraine, where we're working to help provide energy in and out of the country is really now tied to understanding that fossil fuels, in particular natural gas, and nuclear power are going to be transition industries. You can't just shut off fossil fuel and then legislate renewable energy and then hope these countries can get there from here. I mean, I will tell you that pollution is a huge problem in Europe. Lignite coal kills people. They want to get out of that lignite coal. But you can't just demand they stop using coal for energy, and then hope they can get to abundant renewable energy, it just simply doesn't work. And the Russians and the Chinese use energy as a weapon system. So what's happening in Europe right now. And obviously, the Germans committed to the Nord Stream 2 pipeline. And again, we don't blame anybody for not understanding what Russia and China are doing with their energy. But they did not go to COP26. China built more coal fired plants last year than ever before. Russia and China are now dominating the civilian nuclear power industry. Because they understand those are the industries of today and the future, we have kind of committed to a renewable energy strategy that really doesn't play well in the international arena. So how do we fix it? And I think that's really what this conference is about. And I think what we're going to talk about this week, I've had the privilege of speaking on this topic in New York at the General Assembly, I was at COP26, in Glasgow, and we're now going to be going to the World Economic Forum. And we're obviously advocates of nuclear power and the U.S.'s role in civilian nuclear power. And we'll talk a lot today about small modular reactors and how they fit in the future energy mix and how we go back to rebuilding our industrial base and our supply chain. And all the things that Eisenhower talked about in the 50s. About Atoms for Peace, he had it exactly right. So we understand what we need to do. And I think today's conference, we're going to speak on a number of these things. And I could spend all day talking about this, and I want to get into the Q&A, but just maybe to kind of set a little bit of what I think will drive today's conversation is we went to the Paris Climate Accord. And we all agreed on a two degrees Celsius benchmark. As something of a measure of effectiveness, we should focus on not allowing the climate to rise more than two degrees Celsius. Okay. It's a very broad target. It's really undefined. But then unfortunately, what we did, we decided that decarbonization was the solution to that. And then we further shrank the conversation to renewable energy was the solution to decarbonization to the two degrees Celsius temperature rise. And we completely ignored the population growth, the urbanization, the EV market that needs a lot more power, and we kind of boxed ourselves in. So when we were at Glasgow, we kind of scored. How did we do from Paris to Scotland, and we haven't decarbonized one kilowatt of fossil fuel use for energy, because the need for more energy is outpacing the ability to transition. So we have to understand those two things. And in addition to that, we continue to double down on the solution that's not decarbonizing anything. So I want to be careful to say that I completely believe in renewable energy as a key component of every country's energy mix. But it is an all the above approach. So what's happening in real time in the UK, with their energy policy, coming out of COP26, in Poland, and Bulgaria, and in most of the EU nations now is a recognition that fossil fuel is part of a transition plan. So that's great news for us. As we all talked about earlier today, the Russians just cut off Gazprom gas to the European nations. I was over in Bulgaria, hedging our bets, this was about to happen. And setting up LNG deals from the US to Europe, through the pipelines and through building out additional resources, the Biden administration is fully committed to this, which as you can imagine, is counter to their "get out of fossil fuel" strategy. So I think what's happening is that the policies are catching up to the re-

ality that this country has a role to be energy sovereign, we have a role to help other countries be energy sovereign. We should be absolutely operating as the exceptional nation that we are and the world wants us to do that. But we can't flip a switch and produce more LNG overnight. So this isn't going to get fixed in the next year. But we need to start leaning into this idea of US LNG, go back to being energy independent, so that we can help other countries become energy sovereign. I think that's a key part of this discussion this week. Let me just finish with a couple things. Nuclear power is baseload, emissions free, always on, high capacity factor power. Most of the future industries I kind of think of industries in two categories, large, hard to decarbonize industries that aren't going anywhere. And industries that are emerging, that are very power hungry, but want to be green: digital currency, big data, distribution systems producing hydrogen, producing ammonia. These are industries that need a lot of power, that is baseload, but they want to be green. So what's happening is the conversation is starting to narrow down to the kind of electricity that I want. And frankly, hydro and nuclear power, or the kind of baseload, always–on sources of energy that the world is now demanding. And so we should be positioning our country to be the provider of this energy on the world stage, not just from a proliferation perspective, but from a recognition that it creates jobs in this country, it creates revenue in this country. And what we're doing right now is we're reacting to Russia and China's energy policy. And we should have an energy policy that understands the strategic threats from Russia, and China. So I think this conference today is incredibly well timed. The conversation, we're going to have the questions on everything from supply chain, to the industrial base. And what does the industrial base mean for the energy industry, I spent a lot of time talking about the defense industrial base, and how we should take that kind of mindset and apply it to our energy industrial base. There's a reason that we have an industry, an energy industrial base that's fallen into the hands of Russia and China, because we never, we never protected it. The way we protect it, our defense industry, Lockheed, Boeing, Northrop Grumman, Raytheon, we were never going to be dependent upon another country to build our aircraft carriers, or build our US submarines, or build most of our high end defense systems. And we also weren't going to sell it to the Russians and the Chinese. Well, in the energy industry, we've done the exact opposite. We haven't protected it, we've allowed countries to go or companies to go sell their high-end technology to where the market was, which is Russia and China. Westinghouse is not even a U.S. owned company. And it's sold its high-end IP for nuclear power to the Chinese. And now the Chinese are actually exporting our technology better than we are. So the question on the table is, are we okay with that? Or should we take a hard look at how we retrieve that industry, bring it back to America, rebuild it, and continue to advance it. So I could go on and on, David, thank you for inviting me. I'm excited to be here. I look forward to the questions and the conversation throughout the rest of the day. And I'm particularly excited to be here with Tomas, who is living in the conversation that we're having today. So let me just stop there, David, and thank you again, and hand it over.

Dr. Tomas Janeliūnas: Good morning, everyone. Thank you very much. Thank you, thank you, indeed, for the invitation. This is, to say, my first academic conference live after two years of COVID. And I'm really enjoying this, being here and having the opportunity to speak to you. I come from Lithuania a small country in Europe, three times smaller than the state of Georgia, one of the smallest states of the European Union. It is really a small country, but it made a big step, ensuring its energy security in the last decade. And the progress is so incredible, that I could really call it a success story, especially when we are compared to the current situation in the

European Union. And today this situation is not looking so good. The war in Ukraine revealed a terrible situation of the European Union's energy security. It can certainly be called the revenge of geopolitics. For many years, the largest economy. So the European Union, especially Germany, ignored the geo-politics in the energy field and now they are facing a huge dilemma trying to balance morale, politics, and business. As you know, on one hand, there is a war in Ukraine, the most brutal Russian aggression against Ukraine: massacre of civilians. One's political and moral imperative is just to do everything that is possible trying to stop the aggressor or at least trying to minimize the money flow to Russia. And of course, the money coming from the energy exports to European Union is the main source of revenue, providing money and keeping this war going on. So, the moral dilemma is quite simple: how to stop those money flowing to Russia. And Russia is the main supplier for the European Union. Last year, about 40% of imported gas came from Russia. This trend was not changing during the last years, despite more and more aggressive Russian actions abroad, despite unhidden hatred towards Western democracies, and many examples of how Russia was weaponizing energy, and especially on those countries, which are dependent on energy imports from Russia. And Germans are the biggest consumers of the Russian gas. Germany was blind and deaf to warnings coming from Eastern Europe that this increasing dependency on Russian energy sources is risky in many aspects, in many ways, from hindering the European Union aims to decarbonize economies and to move to clean economies sooner rather than later. Too much broader political implications, limiting the foreign policy, foreign policy reactions towards Russian behavior. Plenty of examples are available, that Russia is so skillful in exploiting corruption, and political influence together with oil and gas. The story about the former Chancellor of Germany, Mr. Gerhard Schroeder, a prominent advocate of the Nord Stream pipeline, after leaving his office, became the manager of Nord Stream 2, Director of the board of Russian oil producer at Rosneft. So, this story is just one example how it's easy for Russia to corrupt even the highest level politicians in Europe, then you have such a lot of money coming, coming to together with oil and gas. Nord Stream 2 was just a pure example of geopolitics. After the occupation of Crimea, Russia wanted to bypass Ukraine in transmitting gas to European Union and increase the total dependency of the EU on Russian gas. This was clearly stated by Ukrainians all the time, and by several EU governments as well. The United States also warned Germany not once about geopolitical risks, becoming even more reliant of Russian gas. But Germans neglected every warning and repeated that over and over that this is just, this is just a business. I think that political events confirmed that this is not just a business. This is pure politics. Even before 2022, Russia weaponized gas supply to the EU last year, Gazprom was providing 20% less gas into European markets compared to pre-pandemic levels. So, increasing the true shortages in Europe and the pressure to speed up the panel is the finalization of Nord Stream 2. Because this was the main aim, the main point is to increase gas prices in European markets and to create these shortages, just trying to convey that you know, you can have as much gas as you want, just be fast in completing this Nord Stream 2 by completing some long-term contracts, and everything will be fine. Launched in 2015, and at a reported cost of almost 11 million dollars. The pipeline was finished in September last year but has not been certified by German regulations. And I think that the war in Ukraine made this project obsolete. Right now, Germans are in a hurry to—to get rid of Russian energy as soon as possible. And it is not so easy, of course. They acknowledged already that they made a lot of mistakes during the last decade or two, also, even right now, German politicians are admitting that they have to do something, and it's not so easy to find new ways to diversify energy sup-

plies. As Minister of Finance of the German government, Mr. Christian Linder said, it was a mistake that Germany became so heavily dependent on energy imports from Russia. And he was also trying to provide a kind of explanation of what Germany is trying to do right now. And, of course, yes, it's true, Germany already did some job. The biggest EU country reduced its dependency on gas from Russia, bringing it down to about 40% in the first three months of this year. Also, Germany started to diversify its oil supply, bringing the Russian share down to 25%, in the first three months, and the most recent news is that Germany should find ways to stop buying Russian oil by the end of the year, maybe even by the summer. Just a few days ago, I heard also some talks from German politician that there are possibilities just to switch to the so-called international oil market and to buy oil already, maybe just in a month or two, just keeping aside all their Russian oil and not to being dependent on it anymore. Even talking about gas over the past eight weeks, Germany's shifted delivery change to put some gas provisions, but it's just too difficult to do in much larger scale. But it's good. We can talk about some other resources like coal, and the EU with another sanction round completely banned Russian coal by August, should be just implemented in full. And, of course, the biggest challenge for Germany is coming from gas supply. It will cost too much transforming supply chains in such a hurry. For example, only this year, the German government pledged 500 million euros to help build a terminal needed to directly import liquefied natural gas, only this year. It is just hard to believe that such a country as Germany, until now, has no LNG terminal. And only by this by the end of this year, they are hoping to get their very first LNG terminal and the very first real possibility to replace, at least partially replace, the gas input from Russia. So, the energy security of the EU right now is really a huge challenge, just due to neglection of geopolitics. But there is another story. This is a story about Lithuania. And energy security of Lithuania was and is all about geopolitics. All of the major transformations in energy field during the last decade would not be possible without a clear understanding that what risks come from, is dependence on Russian oil and gas supply. In April this year Lithuania became the first country in the EU to cancel Russian gas inputs. It is an incredible achievement, having in mind that until 2015, 100% of gas has been imported from Russia. Lithuania has no relevant fossil fuels and since 1990, after restoring independence relied hugely on oil and gas input. And all of this came from Russia. We have a long history not to trust Russian companies, Russian energy companies, our suppliers. After declaring independence in 1990, just right after that, the failure was immediately punished by energy, by a full-scale energy blockade. For about four months was no single oil or gas shipment made to Lithuania. And of course, this had a very disruptive effect on the country's economy just in the very first month of independence. Even after the recognition, official recognition of independence by the Russian Federation energy supplies were repeatedly disrupted as well. For a long time, Lithuania also paid a very high price to Gazprom for gas, because no other choice was possible at that time. So, all the major decisions regarding alternative input, info-channel channels were based on energy security first, and only then on economic feasibility or some cost benefit analysis. The first large-scale strategic project was an oil terminal built in 1999. It allowed Lithuania to transform itself from an end-consumer of crude oil to a transit country for Russian oil. And this was the very first step to minimize this one side dependency on Russia. Electricity connections with Sweden and Poland was another step allowing to create a common energy market, together with Baltic countries and Nordic states. Now we can avoid electricity input from Russia if needed and are preparing for the final break off from the Russian electricity system when synchronization with continental European network will be completed by 2025.

But the major breakthrough in securing independence from Russian energy monopolies was an LNG terminal, a floating gas storage unit operating since December 2014. And you guess what the name is? As you can see, it was called Independence, for this reason of course. And this was in political terms, at that time, the president of Lithuania Dalia Grybauskaitė was very clear announcing that we declared our political independence in 1990. But right now, we are just moving to a full independence because without energy independence from Russia, we cannot say that we are safe. So, breaking from Gazprom's Monopoly has led to about 40 or 50% of gas price drop already in 2015. Because Gazprom already knew that it will not maintain the monopoly for gas imports. And the LNG terminal was the reason why Lithuania, right now, is able to declare it is free of Russian gas signs the beginning of April. So, to conclude, I believe that energy and geopolitics will become even more interrelated. As the world in my view is moving away from globalization that we used to see with the United States and the European Union on one side, and Russia, China, other authoritarian states, on the other, becoming competing and even adversaries—some very different political and security entities. This geopolitical reality will make considering energy dependency a crucial liability, which has to be avoided, even regarding the costs. And I totally agree that the United States also has to take a much bigger role in this, because this competition between the democratic world and authoritarian one is becoming more and more aggressive. And speaking about security of democracies, is not only about some political rights, about some military security, but it's even more and more becoming about energy security as well. So, thank you very much. Thanks again for having me here. It's really my pleasure.

Dr. Justin Conrad: All right. Good morning, everybody. Thank you, Tomas, and, Admiral, for your comments. Thank you, for everybody who's here in the room this morning, especially, since you actually made it out to the 8:30 panel this morning, you get extra points for that. But we appreciate you being here. And of course, we appreciate all of the panelists who have joined us who are going to be here throughout the day, many of whom have traveled from far and away, including from other continents. We're very grateful that you're here with us today to talk about what is a very critical and very timely topic. I'm Justin Conrad, I'm the Director of the Center for International Trade and Security here at UGA. And if you give me five seconds to do a shameless plug of the Center, I just want to tell you a little bit about the issues that we work on. So, we work on a range of security issues, issues that are relevant to national and international security, but three of those in particular we spend a lot of our time on. One is strategic trade and non-proliferation. The other is human security. And, of course, energy security. And one thing you'll note about all of those issues, or any other contemporary topic in international security is that they are not divorced from one another. In fact, they are very much interconnected, they are very much overlapping, and at CITS, we take a comprehensive view of security, and we really like to think that we work on the full ecosystem of security topics. Over the last few years, however, my colleagues and I at the Center, we have discovered that despite the importance of all of these topics, energy security is really the foundational concern of contemporary global security. In other words, you know, no matter what we are looking at, if you pull that thread of energy security, all of those other security problems start to unravel at a terrifying rate. And so as Dean Auer pointed out, in his videotaped message earlier this morning, at CITS, we talk about energy security, we acknowledge that it is in fact an economic issue, we acknowledge that it is in fact, a climate issue. But at its core, it is fundamentally a security issue. And so that's the approach that we come from at the Center. That

is the approach that we are coming from with this conference today, which I just learned is actually the inaugural Energy Security Conference, as usual, I'm the last one to get the memo on that. But hopefully, we'll be able to do this again in the future. And we're thankful that you're here today.

Before I talk about energy, specifically, I want to talk briefly about the broader context here. This panel is on energy and geopolitics. I want to talk about this from the geopolitical perspective, especially from the US perspective. So understand that I'm coming at this primarily from a US national security perspective. I'm grateful, however, that we have Tomas here to speak to the European perspective, and the Admiral who has been spending the last few months trying to address the needs of our European friends in this time of crisis. I think that we are, we've already talked a lot about Russia. And we're going to spend the rest of the day coming back again and again to the topic of Russia. But the thing for me that was very shocking, beyond just the brazen invasion itself, was the fact that the United States and our allies were unable to deter Russia from doing what it did. And I think that is actually symptomatic of a transition in geopolitics that has been occurring last at least 10 years or so. And that is that the United States is simply unable to shape the international order in the way that we once were able to do. I don't know why that is. It may be because of capabilities, and it may be because of willingness, probably some combination of the two, we could probably have a separate conference on that question alone. But at the end of the day, there are actors like Russia and China and others, who are very happy to revise the international status quo that has existed pretty much since the end of World War Two. And at the same time, they're very willing to take advantage of that current status quo and to take advantage of the United States and our allies. The good news, I think, is that the United States can counter these malign actors, can push back against these threats, but it is going to take something different in the future. We have always known that the United States is stronger when our allies are with us, but I believe that we are entering a dangerous new era in world politics, where working with our allies is not going to be just a preference anymore, it is going to be an absolute necessity. That's the only way that we're going to sort of hold the line against this rising authoritarian threat that we're seeing around the world. So, the key to preventing crises like this in the future, the key to pushing back against these malign actors is a much more deliberate, multilateral approach to our security. And in the past, when we talked about a multilateral approach to security, we would typically look at that through the lens of military capabilities, specifically, defensive pacts, collective security agreements like NATO—but as we move forward into the future, we cannot afford to ignore energy security. In fact, energy security has to be at the forefront of our multilateral cooperation; it has to be the first thought rather than an afterthought. And just look at what has happened in Europe, you have Russia over the past 10–20 years, using energy as a weapon, as Tomas put it. And it has been a point of contention for those years, and it has been a source of political leverage over the rest of Europe. And what is the outcome of that? It has culminated into what is likely to be the worst conflict in Europe since the end of World War Two. At the same time, you have China positioning itself for conflict against its neighbors, against the United States, in places like the South China Sea, primarily, or at least to some extent, so that they can continue to access the resources, there, discovered and undiscovered in that region. And so, in short, multilateralism is our best defense for the future. But the cooperation with our allies has to place energy in a primary role. And yet, the United States and our allies in Europe and East Asia and Southeast Asia and other places continue to make decisions that make us more vulnerable to these kinds of crises, rather than less vulnerable. We have seen

high gas prices here at home. That of course, is disruptive to our way of life and disruptive to our economy.

And yes, this is partially a result of Russia's invasion of Ukraine, but it's also partially a result of our broader energy decisions and our broader energy portfolio. If we are unable to meet our own energy needs, however, that puts us at a severe disadvantage if we're trying to assist our allies in Europe, as the Admiral has been trying to do. Right, if we have difficulty meeting our energy needs at home, we will have difficulty offsetting the kinds of losses that Europe is experiencing today, that Poland and Bulgaria are experiencing literally today. It will take much more for us to spin up the capabilities to help our allies in this time of crisis. Ultimately, the key to supporting our allies to resisting authoritarian countries like Russia and China comes in the diversification of our energy portfolio, we need to consider all energy options that are on the table. And we need to pursue those options in a way that balances our economic concerns, along with our climate concerns, but once again, placing security at the forefront. Another thing is artificially restricting our energy options. Another effect that it has is that it reduces the amount of soft power that the United States can wield around the world. The United States took an internationalist approach to foreign policy for the last 75 years or so. And central to the ability to do that was our ability to wield soft power. Our reliance on soft power was as important as our reliance on being able to forward deploy our military capabilities around the world. We had successive U.S./American presidential administrations that explicitly tied energy policy to our national security. And somehow, we seem to have entered this point in time, where security seems to be the last consideration when deciding our energy portfolio, rather than the first. Just as an example, some of the work that my colleagues have been doing here at the center, in a published piece, just in the last couple of years, they found that out of all nuclear reactors that have been connected to the grid or began construction since 2000, almost 70% of them were facilitated by China or Russia. The image there is of the Rooppur nuclear reactor in Bangladesh, which was financed almost entirely by Russia, and was developed with assistance from Russia. Now, that's concerning for a number of obvious security reasons, I believe. But I also believe that that's concerning for some less obvious reasons, such as that table there that you see, essentially says that the United States is out of the game, right? And what are the effects of that on American economic opportunities around the world? What are the effects of that on America's ability to shape climate sustainability conversations around the world, if we're not in the game, we're not in the conversation. Just as one other example, from the work we've been doing another one of our recent studies, we looked at the tremendous economic opportunities that come as a result of bilateral and multilateral energy agreements with other countries. We looked at civil nuclear agreements specifically. But we found that when states signed these civil nuclear agreements, they send very strong signals to investors, to private industry, about their seriousness in tackling energy reliability, in tackling climate, sustainability and security. And so, we found that those states see on average, about $1.7 billion more in FDI, than states that don't sign such agreements. And presumably, that effect would also extend to other agreements, such as on offshore wind, onshore renewables, advanced nuclear technology, not to mention oil and natural gas. The problem that I think, and I hope that, you know, this is one purpose of this conference is to start to solve this problem, at least to a small degree, is that public policy discussions and absolutely public discourse on these topics rarely considers these kinds of second, or third order effects of our energy decisions. And so just to conclude, I think diversification is the key to a safer future. Diversification in our national security in terms of working with strategic allies more intensely, more deliberately

around the world, to hold the line against countries like Russia and China. Remember, China has taken an all of the above approach in terms of its energy and not coincidentally, it has surged to its current position of power in the world. At the same time that the United States, we have reduced our carbon emissions to the lowest levels since I believe the early 1990s. That is not coincidental. But also, a diversification of our energy policy. A diversification of the options that we leave available to us will help to make our country more safe, as well as the countries of our friends. I'll just leave you with this last thought here, which is that no matter what we end up deciding in terms of the portfolio, no matter what that ends up looking like, there will always be vulnerabilities, and there will always be risks. And there will always be security risks in particular, just as an example, Indonesia is set to dominate about 60% of the global supply of nickel in about eight years.

Nickel is a critical component of current electric vehicle and utility scale battery designs. That's a problem, because where do you think that most of the assistance and financing for Indonesia's dominance of nickel has come from? China. So, no matter which direction we go, we are going to confront these issues. The key is to minimize, hedging against and mitigating those risks and vulnerabilities as much as possible. Thank you.

Gattie: Let's begin the panel discussion. There's a microphone in your chair, if you're not sitting on it, you'll have to turn that on when you're ready to speak. I want to start with a question. And Mike, I'll start with you and move down the line this way since we just ended with Justin, when, you know, the hot topic right now is Russia and Ukraine. That seems to have elevated the issue for the moment. Last year, we had Texas, we had California, we had the Colonial Pipeline, almost distant memories. What do you see as this event being something that's going to stick with US policymakers and maybe EU policymakers that is different than the past? How's this one going to stick?

Hewitt: Yeah, thanks, David. And I think it's important to realize that the Russian invasion of Ukraine did not create the crisis that we're facing today, that crisis was building for a long, long time, and resiliency of your system is going to become the watchword, in addition to having the all-of-the-above approach to energy, which I agree with, you have to be able to keep your grid going and keep your critical infrastructure powered under man made natural disasters and even worse, and so this entire invasion is about energy. Russia has used energy as a weapon 20 times since the fall of the Soviet Union. So, this isn't something that was in the past, this is in the current and in the future of how they operate. I think in our country, we've seen indications such as the ice storm in Texas, of having a fragile system that doesn't have resiliency built in creates massive problems around maintaining your critical infrastructure. The Colonial Pipeline cyber-attack was a simple ransomware attack that got ahead of our own protective systems. I think it's an interesting conversation on the cyber side to decide whether it's the industry's responsibility, or is it the government's responsibility? Or is it the company's responsibility to protect its critical infrastructure? That's a whole separate debate that's happening in the United States right now. We all recognize that if Russia was to launch a missile attack into America, we would fully expect our government and our military to stop that attack. But a cyber-attack doesn't have the same protective systems. And we're kind of asking the industry to protect itself. That's a very clear indication of we need to completely shift our understanding of protecting our grid and our infrastructure, and ways to do that. I think that, again, when you create a fragile infrastructure system, and renewable energy has introduced

fragility into the system, that we can address. But we need to understand how it has created this fragility. And I think it was said, very appropriately, that Russia and China understand this much better than we do. And their focus is on making sure their countries have adequate energy for growth, and then being able to export that energy for geopolitics. We, on the other hand, have taken a completely different approach. So, I hope these are all clear indications of how our policy needs to address everything that we've talked about this morning.

Gattie: Thank Mike. Tomas, do you see this being a different warning shot in Eastern Europe and Europe in general?

Janeliūnas: Well, of course, this time, this challenge is coming from the war in Ukraine. Of course, it is not the start of the crisis, it is a consequence, when we are speaking about energy security, but something is, of course, very new to say, a new example how the governments are reacting to it to this. And I think that pressure is coming from people, from societies making a much bigger influence on governments trying to change the situation, it is becoming more and more evident. Because when you see all those images coming from Ukraine, just ordinary people understanding that their governments cannot escape Russian energy system, because they were so blind to this, to this weaponizing of energy for many years. Right now, people are kind of awakening and trying to make a bigger pressure for their own governments. And even Germans, for a long time used to just neglect every aspect of energy security, which relates to the dependency on Russia, they are changing their own opinions and the population is making a big call for governments to change that. I think this is the kind of transforming moments right now, because for a long time, many decisions in energy security were made, just purely from their calculations to say what is profitable, it is much cheaper to buy gas from Russia, rather than to build some LNG terminals. Right now, the cost is not the most important factor, the security and vulnerabilities, how you can make decisions and foreign policy, which connects to energy security is becoming even more important. And this is, I think, for some countries is maybe the first time during the last two or three decades. Because they are, right now, just beginning to understand that energy is always a dual-use goods. And you have to be very careful with whom you trade, it's a friend or foe. And if you are trading with a foe, this will always be a kind of liability for you. So, you have to escape it. And I think this will make a quite a big change not only in, say, moving faster, towards greater autonomy, investing more into renewables. But first of all, it's a game changer. When we speak about the minds of people, I think only right now, ordinary people in Germany understand that energy is a weapon. Because until now, only such smaller countries like Lithuania, Estonia, Bulgaria, had such experience about being punished by Russia with energy. Germans were quite good with it. But right now, they are just also moving on the same page, like we are.

Gattie: Justin?

Conrad: Yeah, I'll add that I agree with the statement that this is a transformative moment. I think that we're seeing an acceleration of a transition that has been occurring, which is really kind of a sorting of countries around the world. You know, we went from 10–15 years ago, where we refer to some of these countries, as, you know, competitors, and then strategic competitors, and then potential adversaries. And so today, I don't know how we would refer to Russia, but it's not good. And we see that countries like Russia, you know, where the energy trade is really all about the highest bidder have kind of sorted themselves into one section of the world. And we're seeing an acceleration of the United States and its allies, hopefully, coming together

and working together and pooling our resources to make at least our part of the world more secure. And I think that that's a, you know, an unfortunate reality that we're going to have to deal with. And I think that we've been talking quite a bit about the importance of oil and natural gas in Ukraine, in Eastern Europe, in Europe, and we haven't even mentioned the tremendous consequences that the renewable sector is experiencing in Ukraine right now. I read the other day that the damages to the renewable sector in Ukraine are going to exceed $1 billion. That's the greatest loss of renewables in world history. And so, I think that this transition was occurring. But I think that the Russian invasion of Ukraine has just catalyzed it even further.

Gattie: So, the conversation has been, it tends to be, right now, it's about oil and gas, oil and gas, oil and gas. We are trying to respond to the US, EU, other countries. The first question is, do you see it as tactical or strategic, are there going to be long term policy shifts? But I also want you to address, is this because of Congress about challenges and opportunities here, or for nuclear, advanced nuclear, small, modular micro? Is there a window of opportunity here for us to elevate the conversation because nuclear is struggling in the US, in the UK. France is, seems to be getting back on board. South Korea has a president that's all about it. Is there an opportunity here for nuclear and Mike, you had talked about this in your talk about elevating that back to its appropriate national security level? Do you see opportunities there? And maybe add to that, how do you see that playing out? What is the strategy?

Hewitt: I think, rightly or wrongly, the wakeup call out of COP26, and kind of recent developments is that we can't get to our end state that we've determined without a transition plan, and that LNG and fossil fuel and nuclear power are the key components to transition out of a very heavy fossil fuel industry, to one that's more diverse and clean and baseload. So that's great. It is very strategic in the fact that, frankly, I don't care if all the renewable energy resources come from Russia and China, I don't care if China builds every solar panel on this planet. To me, that's not a strategic issue. It's a commercial issue. I care deeply that Russia and China dominate the nuclear power industry, because it is a completely different industry, from the others when it comes to national security, non-proliferation, job creation, economic growth, our country has prospered on the fact we had over 100 reactors in this country in the 70s, in the 80s, that were built, creating 50% of our clean energy today, even though it's only 20%, of our baseload power. So, recognizing that dynamic, and realizing that nuclear power is an industry that the rest of the world is demanding. African nations–17 African nations are demanding nuclear power, because they see the prosperity that came from nuclear power in the US, in the UK, and in France, and even in Germany. And so, I think that the ability for the United States to reposition itself as not only a producer of nuclear power, but an exporter of nuclear power, gives us so many national security advantages that we don't otherwise get if we simply think about energy as a mix of commodities. So, I think that shift is critically important. And really, this conference is the kind of thing we have to do to reengage specifically on nuclear power. We believe the future is in the small modular reactors. And we could spend a whole hour talking about that, but simply put, small modular reactors are where we're going to rebuild our industrial base, they're going to complement the current energy mix, particularly with renewable energy. They are factory built; they can be tailored to the demands of the country. And finally, they attract private sector capital. So, our work is on financing large nuclear power projects with small modular reactors, because they're investable and bankable. And that's how we're going to introduce nuclear power to the world stage. Similar to the space

industry, where we privatized it. We commercialized it, we exported it. And it actually gave us a more robust national security strategy in space. So, there's a lot here, I think we have a tipping point moment for the US to become an energy independent, energy dominant, energy exporter country on behalf of these other nations.

Janeliūnas: Personally, I'm also favorable of nuclear power, especially investments in technologies. And to say, I see opportunities getting high for this type of energy source. Estonia, for example, this year, is conducting a research study about the possibility to introduce a small-scale nuclear reactor, just to bring it into the composition of the energy structure. They are trying just to move on to this type of energy. But there's still a lot of challenges towards this. And it's also related to the energy security. In, say, theoretically, speaking about theoretical definition on energy security, it's already maybe called classical one about four A's to say, availability, accessibility, affordability (price) and acceptability, to say, how much people are accepting of one type of energy over another. And in Europe, this factor of acceptability of nuclear energy is quite low. Because it was for decades long, there was propaganda and disinformation carried out against nuclear power plants. And you guess what, Germany right now is facing one of the biggest energy security crises this year, trying to diversify energy supplies, trying to find ways how to get, I don't know, better gas contracts with other countries, they're still keeping on decision to finally close the several last nuclear power plants this year, even if they could be fully functioning just for years. They are just keeping on this political commitment to close nuclear power plants because of the public pressure, because this acceptability of nuclear power plant and in nuclear energy in Germany so low, even in Lithuania, ten years ago, we had a project to introduce a new power nuclear power plant. And it was a failure, not without Russian interference, of course, because it was made a huge effort to create propaganda, disinformation on that political influence, corruption, whatever. But the last decision was made also because of the low public support for nuclear energy. We had a referendum 10 years ago, and people said, "no," we don't want nuclear energy. So, investing in this kind of energy security, say, to increasing the acceptability level, within the population, I think this also must be kept in mind that it is also very important element of energy security.

Conrad: Yeah, I agree that nuclear needs to be an important component of our energy portfolio, not just for domestic supply, but in our trade with the rest of the world. And I think that the reason why we sometimes seem to be moving in the opposite direction with nuclear always, you know, the perennial concern is the stigma attached to nuclear power generation. Ironically, I believe as a result of Chernobyl, of Russian management of one particular nuclear asset. And, you know, an event like that, which is once in a more than a generation, that we see things like this happen really has created a very difficult public perception regarding nuclear power. And you know, I think that that's why we have been often headed in the opposite direction. I think we've decommissioned like 11 reactors here in the United States in the last few years. We're set to decommission another nine of them. I wonder if there will be a change in some thinking about the wisdom of that approach going forward, given this crisis, but because ultimately, I think as much as there may be a stigma attached to nuclear power, I would think that there's a greater stigma attached to the kind of crises that we're seeing in Ukraine right now.

Gattie: So you've all mentioned US leadership engagement. And once we get through this question we'll go to the floor. So I'll ask this question. We'll come down the line then we'll go the floor for questions. Our current security alliances, and what we've heard in the past about particu-

larly whatever the resources are in here, we're talking primarily about nuclear and natural gas. Those are kind of the two that are of concern. When you look at our current security alliances, whether it's NATO, Five Eyes, the Quad, even Tomas over in your area, the Three Seas Initiative. If you think about things like nuclear and natural gas being Team America, how can you shift that over to an allied–I mean, how do you see allies and security alliances playing in to a much broader US engagement, Mike?

Hewitt: The mistakes we've made in the nuclear field is this Team USA approach, when in fact, we don't have the natural resources, we don't have the skill sets, we don't have the supply chain. And we haven't built a reactor for 30 years, our allies are in somewhat of the same state. So I think when we talk about energy security, particularly nuclear power, we believe that it has to be an allied approach, specifically, what I would call a Five Eyes approach, if you're familiar with the Five Eyes alliance of the US, the UK, Canada, Australia, New Zealand, that's a Security Alliance at its core, but it allows us to share technology, and allows us to think, in a group of closely aligned allies, I think, for civil nuclear power, we need to be thinking through a Five Eyes lens, when you look at Canada and Australia, they have all the uranium in the world to produce civil nuclear power for centuries. The US has an unbelievable skill set and safety and security, even though we may not have the commercial prowess that we used to have, the UK is front and center in replacing its own nuclear power systems, and unfortunately, has allowed the Chinese to come in and actually finance their nuclear power program. So, take a step back, create a Five Eyes approach, focus on the Three Seas Initiative, focus on the Quad, these are alliances that are already thinking in a bloc. And they're all concerned about Russia and China's influence. So, I think a Five Eyes approach to civilian nuclear power, tying in all of the industrial base issues that we talked about the average rate payer, and we could talk about Vogel for just a second, I just want to touch on this. It's not the ratepayers' responsibility to pay for national security, it's the taxpayers'. So, let's elevate this conversation of why we need a robust civilian nuclear industry. Present that to the taxpayer as a national security strategy, walk them through why this conversation today is so important to their security and their children's security, and helping our allies stay out of the influence of Russia and China. And I think you will see a robust commitment by this country to energy security. So, I think we just have to reframe it a little bit, David. And I think the average American citizen listening to this conversation would agree to it. But if you just keep saying your electric bill is going to go up, because of cost overruns for civilian nuclear power plant, you're going to lose the audience. So, I think that's why we're talking about reframing this through an alliance approach.

Janeliūnas: Say, I totally agree that this policy of Alliance approach should predominate right now, when we speak about energy security, and we have good examples in the military sphere to say how the security issue could be elevated to how this can become a priority. For example, we have this military, NATO nuclear sharing policy. Why not take this example and create a kind of strategic energy reserve, that could be used also, in the same pattern to say, have this status of allies, new allies, energy sharing reserves or something like that. But first of all, I think the priority to trade with allies should be made on a strategic level, to say not only trading of energy resources, but also providing technologies for energy. This is even more important than just ordinary trade of energy. And this relates not only to nuclear or some more sophisticated technologies, but even for the renewables as well, because dependency on critical material needed for renewables such as wind and solar technologies. Right now, China owns two thirds of materials and technologies needed for solar panels. The battery market is even worse,

about 80% of all batteries are produced in China. So, this is also a new pattern of asymmetric dependency. So, we have to take into our minds this tendency and to transform our thinking that this is just a business, I think it's not, we have to think about security components.

Conrad: I'm really glad that we ask this question, because I feel like it's the perfect way to implement, especially in the short term, what I was talking about in terms of multilateral energy security, that this is the low hanging fruit here, that we have these institutions that already exist. And we need to elevate energy security in the context of those institutions as quickly as possible. And that this crisis, I think, has made it more apparent to those institutions, that that's going to be necessary. NATO, in 2008, was the first time that they produced a paper on energy security, at all. And the development of that paper was very difficult, because there was a lot of disagreement over whether NATO should be concerned with this or not, or what NATO's proper role in terms of energy security is, fast forward to now, it has been elevated tremendously. And not just because of Russia, over the last 10 years, there was an understanding on the part of NATO members that terrorism and piracy and cyber-attacks, you know, constitute just as much of a threat in many cases as Russia does, and Russian dominance of energy. So, I think that there was already a growing appreciation that we need to put energy security at the center of these multilateral institutions. And there's tremendous opportunities in NATO, and for the Quad and others to explore these. The Quad got me thinking as well about how, you know, we also need to place renewed emphasis on bilateral cooperation on energy security, India provides a tremendous amount of opportunity to ensure greater security for the United States and for the world. Since we signed a civil nuclear agreement with India, in 2008, our security cooperation with India has grown tremendously. Less than 1% of India's Defense imports came from the United States back then, and now we're closer to 10%. And, that is not a coincidence, that has developed along with our energy cooperation. So, they are mutually beneficial to one another. And I mentioned this, you know, potential sorting of countries around the world. We want India to sort into our camp, not into the camp with Russia and China where, you know, they feel additional pressures as well, because of where they're located, potentially, to do business with Russia and China. But we want to shore up our allies, our strong allies, such as India, as much as we can.

Gattie: We'll now open the floor up to the audience, please look out for students with microphones, and I'll holler, and point out people. We'll start here, Gary?

Dr. Gary K. Bertsch: I hope you'll let me begin on a personal note, I've been coming to and involved in conferences like this, in this building for over 50 years. And I want to say to our panelists and to the organizers, I don't think I've ever heard a more important or wiser discussion. This is really, really important, and really well, well done. And the competition has been high, because 25–30 years ago, we were having a lot of conferences dealing with the collapse of the Soviet Union and what to do about all of the nuclear weapons and proliferation of advanced weaponry coming out of that part of the world. We had a number of secretaries of defense, William Cohen, Bill Perry, Bob Gates, senators like Nunn and Lugar. But this is really important stuff. I might also say that at the end of one of those conferences, a woman walked up to me, I was in Justin's role in those days, and I was happy to get the conference over and we were just leaving my wife and I and this woman said to me, Gary, can the Center for International Trade and Security use a million dollars and she pulled out a check and wrote a check for a million dollars to the center. So, before you leave today, I considered doing the same thing. And then

when I retired, she wrote another check that resulted in the job that Justin has today. So, I want to ask Admiral Hewitt, because I'm so pleased to see that the University of Georgia can be involved in such things and play a role in bringing people together and doing important things that make a difference to our country in the world. So, what advice would you give to the Center and to the University of Georgia and other universities in how to enhance the role get the US to play a bigger role in bringing about the kind of change in the policy that you and the panelists have been talking about this morning?

Hewitt: Thank you, Gary. And I think because of you, we're here today, in many respects, and so great question. I think if we go back to the heyday, of the labs, in the universities, and where our strategic thinking was emanating into our policymakers, and into our congressional leaders, it really was at the university level. Of course, we had a lot of lessons learned out of World War Two and other things that shaped our thinking. We've lost a lot of that. And I think the ability to retrieve it exists here at the University of Georgia, I look at things like the Aspen Institute, and I look at others, the Hudson Institute. And why not think in those terms with this topic. Because I think this is the kind of topic that we can create that kind of institution. So, I would think extremely big to Justin and David, on this exact thing. This topic alone is one that's informing the thinking of every national security leader as we speak. It's amazing that this isn't happening all over the place. So, it's not. So, we have a unique opportunity, you have an unbelievable organization that's already poised to do it. And I think this conference can set the scene for maybe a lot of checks, a lot of thinkers, but let's go back to informing policymakers through the lens of your organization, because it's the students that are going to be our future policymakers. And if we don't start investing in them now, we're going to miss this. And so, it's a great question. I think this is the kind of conference that next year, I can envision a whole other group of people here that will be advancing this conversation. And we're already talking about who we want to have here, next time. So yeah, this is great. And I really appreciate the opportunity to be here.

Gattie: Yes, ma'am. We can run a microphone over there to you.

Dr. Valerie Thomas: I'd like to thank all of you for your presentations and comments. And I agree with what you said. And this was the session on geopolitics. So, I want to bring up politics. Um, my interpretation of some of the responses in Germany, and in France to, you know, the energy crisis there is concerned not just with what is possible to do in the European Union in terms of reducing natural gas use and petroleum, but also concern about the response of the public, that there is I think real concern that if there are skyrocketing, or just much higher, or even not very much higher energy prices, they'll really lose the population in terms of the overall, shall I put it—fight, you know, with Ukraine, so I'm interested in, so I'm seeing them—It's not just what can we physically do? What can we do with our economy? But how do we make sure that the population stays with us in a united way?

Janeliūnas: That's a great question. Indeed. Because I'm not sure that the governments in Europe know the answer and right now, that is the biggest challenge: how to pursue a huge population to pay the bigger price for energy, and at the same time, to be, say, more moral in solving this crisis in Ukraine, because even within the population, there is no uniform opinion. There are people who are more ready to pay some higher price just because of some altruism or something like that. But of course, there are a lot of people who think about their own budgets, of course every day, and it's just the world as we have it. I think that for the governments, this

big challenge, how to make a clear connection. For what we're paying to say, what comes with this bigger price for energy? Are we paying for the lives in Ukraine, for some blood spilling there? Are we paying for better sleep at night, or paying just to say, to keep our ordinary way of living? This kind of rhetoric, this kind of political messages is very needed. And I'm afraid that for many years, our politicians just forgot to connect very clear moral dots to say, you have to explain people in very clear terms, why they have to pay just bigger price for energy and what they got from it. And after such explaining, right now, this is the right moment, because this is such a dramatic situation, just going on in Ukraine, you can show very clearly what is mean, to pay for Russian gas to say the same price as it used to be, or to pay for LNG price coming from United States, but be more secure, be more moral, and be not supportive of the crimes committed in Ukraine.

Hewitt: When the consumer sees his electric bill, skyrocket, or not have the electricity. So, what happened in the UK were rolling brownouts, were skyrocketing electricity prices. And the consumer looks back to their government and says, "why is this happening?" And so, I think we owe the consumer a redressal of this. When did we decide that there's only so much electricity we should be producing, and that energy poverty is a good strategy? And that's really where the consumer is now asking these very hard questions. I think Germany is struggling right now, with its energy policy, because they did commit to getting out of nuclear power, they did commit to an overabundance of renewable energy. And they committed to a reliance on the Nord Stream 2 pipeline. So, three things have occurred in Germany, since that decision by Merkel, their electricity prices have skyrocketed. They are producing more pollution and carbon today than they were before that decision was made. And they are now extremely committed to the Nord Stream 2 pipeline for their energy future. Those are three things from a geopolitical perspective, that don't match up to what the politicians have been saying, or trying to do. So, I think there is a real reckoning by the consumer, they're more than happy to invest in climate change and clean energy solutions, as long as it's also addressing the need for abundant power for emerging market nations. So, we have to balance those two things. And this is exactly the conversation that's happening in Europe right now on the heels of COP26. So, I think the crisis has given us an opportunity to have this conversation. I think the US, and I've said this, that the hubris of the United States and the UK to talk net zero, when in fact, we're not actually delivering on any of those policies that we said we were going to do in our own country, let alone kind of legislating that other countries must skip the Industrial Revolution, and be part of the climate change solution. That's just not—it doesn't sell well. So, I think we have to really take a hard look at the geopolitics of our energy policy and recognize what the average consumer thinks about every day. And that's been the wakeup call in Europe. And the final thing I would say is energy prices and food prices and water scarcity and food scarcity, haven't even begun to manifest themselves yet based on these decisions. So, in Europe, most of the fertilizer and ammonia that was being produced to feed the world has really come to a complete stop, because the price of energy went so high that the ammonia plants couldn't continue to operate. So, you haven't even begun to see—forget inflation. Food scarcity is going to come to our shores very quickly. So, I think this all goes back to energy policy that needs to address these other dynamics other than just decarbonization.

Commissioner Tim Echols: Admiral, first of all, I love you, man. I love you. You're just—you're incredible. We need to keep you down here in Georgia. I really appreciate your perspective. My question is to you,

Admiral, in 2018, we were holding on for dear life at the M triple F plant at the Savannah River site, where we were fulfilling our geopolitical obligation with Russia to basically deconstruct nuclear warheads. It was an "I'll destroy mine if you destroy yours" type of a deal. So, we were building that we were over budget it was taking a long time. Yes, yes. But on the other end of the deal was the Russians agreement to do the same. Unfortunately, President Trump canceled the deal—got out of the agreement and canceled our facility. My question to you is this. That was four years ago, when we had a much better relationship with Russia. When we weren't worrying about nuclear warheads being used on Ukraine or anyone. Today, it's a different story. What difference might it have made, had we continued with our work there? Use that MOX fuel at plant Vogtle, which we can, with those reactors which can be retrofitted, where we had our own fuel, our own source of fuel indefinitely. What do you think about that decision in '18, to cancel that facility, and terminate our agreement with Russia?

Hewitt: There's so much in that question, Commissioner. And I will tell you that we were actually leading the charge of finishing the MOX facility, which allows us to close the fuel cycle. So, if you understand the ability to take fuel and reuse it, that was core to that conversation. Savannah River, and VC Summer, to us, was our ability to get back into the game, so to speak, with nuclear power. Unfortunately, we didn't have a program that was supported. And the Department of Energy, I believe, did not understand how challenging this was going to be—the megatons to megawatts program, which is really what you're referring to which we allowed an unbelievable program to draw down and reuse into a civilian way to reduce warheads was a great program. And it's still a very, very important program. Unfortunately, it also made us lazy in our own enrichment capability. So, in the mid–80s, we produced 100% of the enriched uranium for the world market. Today, we produce none. We get it from Russia, and we get it from international consortiums. We can't even enrich uranium in this country to fuel our own reactors. So, part of this decision of the concern over Russia is that most of our fuel comes from Russia, for our civilian plants. And when you have a foreign policy that says I'm going to sanction the Russians, over their deal with Iran. And then we have, bluntly, the NEI and the nuclear industry arguing against those sanctions, because they don't want the price of their fuel to go up. What that tells me, and I think what you're touching on is that we no longer have an industry that we can count on for national security purposes. I think it was criminal. To stop the MOX facility, I think we can go back and still revisit that. I had this very conversation with Governor McMaster three years ago, and said, Let's tie this to national security. Let's come up with the resources to do it. The future of nuclear power has to be in the fuel cycle on the front end and the back end if we are going to be part of this industry. So, I think it's maybe the time to go back and revisit that right now and I think that's something we should pursue collectively.

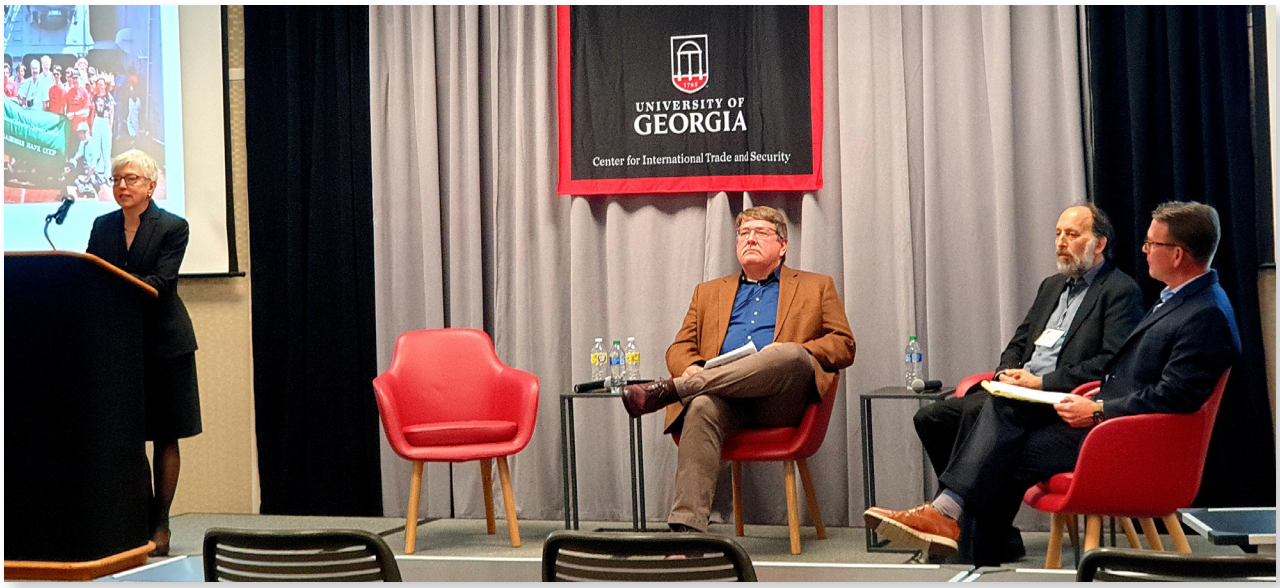
Dr. Rich Axelbaum: So, Admiral, you had mentioned that Russia and China, they understand energy as a weapon and the United States and EU really don't seem to understand that. And one of the clear reasons for that is because policy in Russia and China isn't dictated by the civilians and in the United States it is. And when that happens, you know, I think about in a well, you know, we're really framing this in the beautiful meeting here, I'm really happy with him and impressed with everything that's going on. But it brings to light that, you know, we're really dealing with something that we've looked at two different types of entities. We had the DOD, and they with DOE and DOE's role in the past was really what it should have been, it was just building energy infrastructure in the United States. But this, this conference is framing, it's not just

that it's a strategic issue. And so, we have a department that really isn't appropriate for what our needs are right now. And the structure of it, since it's really very much administrative based it flip flops every four to eight years. There's no strategic planning in the DOE. It feels to me like for us to get over this hump, we almost have after a separate organization, separate department, a Department of Energy Security, or something that bridges with the DOD and DOE to have some type of planning that really lasts beyond administrations that can be very strategic. And that to me, that seems like I would want to have but is it really possible for something like that? Or is there an alternative, that can really put us in a position to make long term decisions that work with both respect to energy and strategic needs?

Hewitt: So, the Department of Energy is a lab, academic based organization that works on certain research projects, continues to keep the labs alive, it is not in charge of national security. But unfortunately, we've allowed them to kind of own this conversation. It's out of their purview. Part of this, this conversation that David and I've had for last few years is "move this over into the Department of Defense." Intelligence community, the Foreign Relations community, the Armed Services Committee, get out of just Energy and Natural Resources. This conversation has been pigeonholed, frankly, in a DOE energy commerce conversation, for the levelized cost of energy, when in fact, this entire conference is saying no, it needs to be over here. So what we would like to see happen is an executive order, I'm just going right to that "ask the Department of Defense to build an industrial base" conversation around our entire energy infrastructure, not just nuclear power, understand what it means to abdicate that to Russia and China, understand what it means to go back and rebuild this industrial base so that we are resilient, and we can rely upon our own country for things that really matter. And I think that conversation is uniquely positioned in the Department of Defense. And what the DOD has done for the last 50 years, is create a beautifully organized structure between the Congress, between the industry: Boeing, Lockheed, and everyone, and the consumer who is the military, they operate with one voice. They operate with clarity to the Congress, and the American people. To your point, the citizens really understand what it means to have an industrial base, they're willing to put their taxpayer money behind it. That conversation is not being brought to the American people who need to make these decisions. So, I think moving into the Department of Defense, making this a national security interagency conversation will inform the American people and allow the DOD frankly, to go back to what it should be doing much better, which is helping us map out a lab and academic organization and the NNSA of course, which is a unique capability that they possess and need to continue to possess. So, I think it's a great question. I hope this conference in some way allows this to happen at the interagency and at the national security level, and I think it will.

PANEL TWO

Energy Resources and Technologies



Left to Right: Dr. Valerie Thomas, Mr. John Harju, Dr. Richard Axelbaum, Dr. Josh Massey

Dr. Joshua Massey: All right, well, good morning, everyone. I'm Joshua Massey, I'm a senior research associate at the Center for International Trade and Security and the director of UGA's Master of International Policy Program. I'm going to be the moderator for our second panel this morning, which is entitled Energy Resources and Technologies. And so the first discussion that we had today was focused on the geopolitical implications of our energy decisions. That is, how do nations use resources and relationships, their energy resources and relationships, as an instrument of power so that they can influence behavior across the international community. And so what we've intended is for this second panel, to be more focused, and perhaps use this as an opportunity to go in-depth a little bit more in regards to some of those specific resources and technologies that we are talking about. Really the foundation for those decisions that we are making all can be grounded in the technical limitations or the advantages that those specific resources or associated technologies have. And so it's important when we talk about "an all of the above strategy" that we take a look at what are all of the options that we have in making our decisions. And so that's part of the discussion that we're going to begin having here this afternoon. We are fortunate to have with us today three experts that are going to help us animate that discussion. First of all, Dr. Valerie Thomas, Mr. John Harju and Dr. Rich Axelbaum. Dr. Valerie Thomas is the Andersen Interface Chair of Natural Systems and professor in the Milton School of Industrial and Systems Engineering at the Georgia Institute of Technology. So welcome Valerie. Mr. John Harju is the Vice President for Strategic Partnerships at the Energy and Environmental Research Center at the University of North Dakota. John, thanks for being here with us today. And Dr. Rich Axelbaum is the director of the Consortium for Clean Coal Utilization, and head of the Laboratory for Advanced Combustion and Energy Research at Washington University in St. Louis. And so real quickly, what we will do at the beginning of each panel is, before we jump in, just give a few reminders about the format of our panels and our rules of engagement. So again, this panel is going to last for one hour and 30 minutes. We'll begin by giving each panelist 5 to 10 minutes for opening comments. At the conclusion of their opening comments, I have some questions that I'll use to kick off the conversation. And then what we'll do, again, is open the floor to questions from the audience. I'll just emphasize and we've been asked to make sure that everybody knows that if you do have a question, raise your hand. And of course, we have students that are carrying microphones. I'll say what is important about speaking into the microphone is much less about the projection of our voice. This room has pretty good acoustics. And so I don't believe any of us have a hard time hearing each other. But it's more about ensuring that we capture the discussion that's going on for the transcription which we hope to produce later. And so that's why it's important to make sure that we speak into the microphones. Okay, with that being said, I'm going to go ahead and turn it over to Dr. Thomas for your opening comments.

Dr. Valerie Thomas: Thank you, and I have a few slides, I don't know if they're available to be shown. Yeah, okay. There we go. All right. I am starting with this slide because I didn't want to end with it. This shows *The Moskva* used to be called *The Slava*. It was shot down. It sank a couple of weeks ago. I heard that at least half the crew died. There I am on the Slava some years ago, when we were doing some experiments with the Soviet Academy of Sciences to detect nuclear warheads. This was a time of warming relationships between Russia and the United States. Yeah, there was a nuclear warhead in that cruise missile launcher right there above my head. And yes, in fact, we could detect the radiation coming from a nuclear warhead, this was part of the START 2 negotiations about sea launch nuclear cruise missiles. As part of that same time, we had many

colleagues in Russia, and they started a center for Arms Control, Energy and Environment at PhysTech, Moscow Physical–Technical Institute, where I have many colleagues. That technical analysis organization had to be shut down some number of years ago, because they had international contacts, and were therefore considered to be foreign agents which they certainly weren't. And now we have almost no relationships, no active relationships. So that's a problem. So I'm showing this also, as an indicator that technical people can come together and come up with ideas of how to solve challenging problems. We were showing that yeah, it is possible to detect nuclear weapons. And there are lots of methods and we tested them out there on the Black Sea just outside of Sevastopol. Today, I brought just to start out the conversation, a few ideas of technologies that I think can do with a bit more attention than I've been hearing in the past month. So one of them is weatherization. Thinking about regular people and their energy security. There's been, I think, just the wrong language around this, that somehow it's just not worthwhile. But if Germany and the European Union do a much better job on reducing the energy requirement, being smarter about how we're using energy and raising our level of conversation with people about what they can do to save money, they can save money and have greater energy security and more comfort. I think we should do that big time. And then as part of doing that, that sets the stage for—you don't have to use natural gas to heat your house, you can use electricity. Of course, you can run right now down to Walmart, or wherever we want to go and get a resistive heater, right this second. And it's not even very expensive. And just like 1500 watts in case you don't talk about watts and stuff like that a whole lot. It's like a toaster. It's like a toaster or a hairdryer. And it works fine. On the other hand, there's been a lot of discussion around heat pumps. So why would you want a heat pump, it's more expensive.

And on the other hand, it works kind of like a refrigerator. So typically, it would have what they call a coefficient of performance, about three, that means you get three times the energy out of what you put in, which sounds like it's breaking some rule of physics, but it isn't. So for the same, pretty much the same amount of energy as your toaster, you can heat your whole house with a heat pump. And I know that in Germany, they're working to install these as fast as they can. We've been talking about shipping some to the European Union. So this is really a good idea. It's more energy efficient, and it saves money. And I think that we should put a lot of effort into not only the need for more supply of natural gas, but just helping people to do something different. They will be more secure. Completely on the other end of things is thinking more deeply about not just energy, but the entire industrial infrastructure that is using energy. So not only about supplying energy to keep the same oil industry that we've had, but thinking about what are the industries of tomorrow. And one of the challenges is the Haber-Bosch process that makes nitrogen fertilizers. That is one of the largest uses of industrial energy. I think it's okay to say we need fertilizer, we need nitrogen fertilizers, there are other ways. First of all, we can be more efficient in some countries, and we can manage if there's going to be less fertilizer this year, if we are, again, really thoughtful about use of that fertilizer, this shows some countries that are using fertilizers less efficiently than others. Also, did I miss one I had wanted to discuss, maybe it's coming in another slide. But I'll go here to hydrogen. In January and early February, finding an alternative to natural gas in industry was just not on anybody's agenda. It was totally on the agenda to not have any greenhouse gas emissions from industry. And the way industry was going to do that was to capture the carbon dioxide, which we're going to talk about later. And it's just fantastic. But how could you have a chemical industry without natural gas? That's more challenging, it's not fast. So what about

this green hydrogen? But it just means hydrogen made by splitting water? And how much is that going to cost? It's going to cost some and it uses electricity. That's what electrolysis means. I just worked out if you have the cheapest electricity, you can manage maybe two cents per kilowatt hour that the minimum cost of hydrogen is about the cost of natural gas today, so it's not that far off. And then of course, you have to have the infrastructure. So it's going to be about twice that again. So it's expensive and is going to take some time. But it is viable. Then here's what I wanted to talk about more with the fertilizer. We don't have to use the Haber Bosch process forever. The Haber Bosch process, as we've heard, fertilizer, nitrogen fertilizer, ammonia is made in Germany. And at large scales, you cannot beat that in terms of cost. But that fertilizer is transshipped through supply chains around the world that adds cost. So there are alternative solar ammonia, major research to Georgia Tech, that is about the same cost for smaller scale markets that are not near to these big Haber Bosch plants. So that is an option. And then thinking in the longer term, plastics. That one's tricky, because they use natural gas and other fossil fuels to make it but the plastics have carbon. So you need a carbon source for that. There's been some interesting work on working through "how could you have a fossil fuel free plastics industry?" And there's a lot going into that. Some of that is making sure we don't throw out our carbon. It's much more economic to recycle the plastics into other plastics than to say, burn them for energy, although you can do that. And then some capture of carbon from the air or from other sources to make up what you've lost. So that's just a few ideas that I throw into the pot.

John Harju: Well, thank you, in particular, David Gattie for inviting me to come down to Georgia and get out of extended winter coming in from North Dakota, which is place with roughly five months of winter, five months of summer and then a couple of swing seasons that we call spring and fall and they're almost impossible to differentiate from one another. And I just thought I'd give you a little bit of my musings over my career in the energy industry, and over some time. And, you know, just a sprinkling of, you know, words of wisdom from people much wiser than I that have stuck with me over time. And the one that really resonates today is something that our governor likes to say is that we need to provide energy to our allies, as opposed to buying it from our adversaries. And it just really resonates and as we think about the policy measures that we're pushing today that would essentially stifle domestic production. And the obvious influence of that on, you know, global supplies, security, etc. And then, you know, some words that my dad used to always throw out, there was some cheap food, cheap fuel, and cheap housing is what made this country strong. Gives us disposable income, it allows us to dominate that global landscape. Those are the things we need in this country. So obviously, I decided I'm going to get into this petroleum business, you know, turned out to be an awful mistake. You know, as soon as I was out of college, this is, in the wake of the 70s, just an awful time to become a petroleum geologist in the early 1980s. Just just awful. You know, "Hey, waiter!" That's how you found a geologist. But it's really interesting how we got there. So, you know, here's one of my tenets: bad information leads to bad policy. In the 70s, we were under this premise, you know, hey, we're out of oil. Peak Oil is upon us, we are dependent on Middle Eastern nations for that oil. And our policy measures were 55 mile an hour speed limits, turn down the thermostat, mandatory carpooling. And really, just the whole entire notion of energy conservation was the mantra. That's what I grew up in. Gas lines, etc. All based on this premise: we don't have oil in this country. And, and we passed something called the Fuel Use Act that precluded us from even using natural gas to generate power. What happened in the wake of that is, you know, a number of really interesting things. Technology

started to create supply. We had a huge build-out of coal fired power generation, because the Fuel Use act mandated that you needed to build supply from the least cost option. And the abundant coal resources of the nation allowed us to build an incredible fleet of power generation in the country. Then we started to think about, well, let's roll back these speed limits. These carpools that we've been forcing everyone on are actually incredibly inefficient, because we're paying humans to do nothing other than drive around and pick one another up. And fuel is actually relatively cheap, when we start thinking about human wages, and so on. So, you know, things began to evolve. And instead of energy conservation, we started talking about energy security. Could we be secure? Could the United States, Canada, Mexico, sort of North America, be somewhat self-sustaining? And of course, oil was always a little bit one of those outliers. Not, not all there. And then people started to challenge this notion, a little bit of, you know, is this scarcity, really the paradigm or is abundance, really something that we can create with technology, and, you know, through the use of horizontal drilling and hydraulic fracturing, we absolutely witnessed that. And so all the way up to 2019. For the first time, in 62 years, the United States was a net exporter of energy. Three years later, things are moving in a different direction. Again, our predominant paradigm now is, you know, in just a step back, so that energy security kind of got to energy independence. And, you know, God forbid energy dominance was something our last administration was throwing around out there. Now, does that have an effect? In the world? You bet it does. And, and I think we're actually feeling some of that today, that when people realize that that's a possibility. Wow, the landscape starts to shift. Now, how quickly we flip this paradigm, you know, just one cycle in Washington, D.C., and, you know, carbon, we've got to, we've got to not emit carbon at any and all costs, and there's technological pathways that a lot of people were working on for a long time, we have a number of maturing carbon storage projects in North Dakota at this time. But the paradigm is no longer really about carbon, it's actually "leave it in the ground. We don't need fossil fuels, period." And even in the wake of what we've seen in Eastern Europe, the day after, you know, very high ranking officials of our government are throwing out this rhetoric of, hey, we need to keep our eye on the carbon ball. Again, I contend there's a technological means of managing carbon. And back to that bad information leads to bad policy. You know, when we first started to push a renewable penetration in the country, we're nominally 80 to 83%, fossil energy dominance of our energy use. In 2019 was 81%. So in spite of all of these massive subsidies, all of these things that we've done to proliferate, they barely move the needle. And in fact, if you look at, I think, most credible analyses of how we're able to penetrate renewables, just keeping up with global demand, with current market share is actually a challenge, especially when you start to think about some of the rare earths other precious metals, things that are needed for an entirely renewable society. As a former assistant secretary of energy told me, "Hey, we need to focus on the emissions, not on the fuels." And I do think that that's a, you know, a very prudent thing for us to do. I liked the comments earlier about, you know, for anything to be realistic, it needs to be abundant, affordable, accessible, and acceptable. And I really liked those comments. I think about electrifying our transportation. And, you know, it's a great project for the students here to, you know, take a look at just how much of domestic carbon emissions comes from privately owned automobiles, you'd be stunned at what a tiny portion of domestic carbon emissions come from domestic automobiles. Give me a number that is less than 10% of our total emissions as a society comes from that. Yet, there's this notion of "we're going to decarbonize transportation by incentivizing people to you know, buy those electric automobiles." It feels good. Yeah, sure, it

feels good, it looks good. You see it on the highway. But it really does nothing meaningfully, in terms of other policy measures that are there and that are available. Not to mention that today, renewables make up less than 20% of the electric power we have. So at the end of the day, you know, between nuclear and renewables, they're about equal. Abundant natural gas, which has actually gone up 50% domestic production in the last 20 years, is enabling technology for renewables because of the intermittent nature of those renewables. The gas allows that quick on the back of that renewable supply up when it's not there. Finally, I am, I work at a place that was originally commissioned in 1951. Under the US Bureau of Mines, with a singular mission of coming up with uses for the low rank coals of the western United States. We don't see a whole lot of demand for that kind of work any longer. Most of our work over time began to evolve into helping the domestic coals, one, compete both environmentally and economically with other with other challenges. You know, but now, I believe the last number I saw was that we're down to 62 coal plants operating in the United States of America. Again, carbon management is something that is available to us. We have abundant coal resources. And I think we're abandoning technology, for dogma and at the expense of security. Probably a great place to stop and all sit down and look forward to the conversation. Okay.

Dr. Rich Axelbaum: Hello, everybody. Thank you very much for inviting me to this conference. I've really enjoyed it, I think this is game changing. Hopefully we can have something really meaningful come from this. I think the mindset that we have in this conference is very important. I am the director of the Consortium for Clean Coal utilization. So that is going to reflect on how I perceive the challenges we have with respect to security. And one of the primary focus areas of this is going to be discussing what really is the prevailing perspective in the United States and Europe. And that is the future is wind and solar with natural gas is that transition fuel. Okay, that mantra has created a lot of challenges, as we've seen. But I want to step back a little bit if I can, to frame this problem. And to do that, I think that we need to do a little bit of historical reasoning, and this is probably what I think is one of the most profound statements that you will see in a long time. It was by Carnot, so everybody that gets frightened about when you hear about entropy, the second law of thermodynamics, this is the person that was really responsible for that entropy, that whole concept was what allowed us to have efficient machines, okay? This is the person that's responsible for that. He lived in the time of 1824 He understood a society that we will never understand. And what he states in this treatise, is a very important, effectively a prophetic statement. And this is in 1824, the ability to produce at all times, and all places, heat and the impelling power, which was relative, seems destined to produce a great revolution, the civilized world. And of course it did. So the key points you have to see is from his perspective, what's important, the thing that is going to revolutionize is that the power is at all times and in all places. So I sort of see Carnot's law is, if you don't have a replacement for these combustibles, that gives you it where you want it. Or when you want it, you're violating a fundamental Carnot law. And he understood it better than we will ever understand it. Okay, and so I just put it this way power when we want it where we want it. And that's what fossil fuels gave us. And that meant that our lifespan has more than doubled and our standard of living has been like that of kings of the past. But there's a more important thing that has done for us. And that is it revolutionized our population. You know, before the Industrial Revolution, Europe started in England first. So look at that, as the industrial revolution takes off, populations took off, look at the rest of the world, you know, as they were infiltrated into the rest of world over time. And then of course, the populations took off. Now remember, penicillin wasn't invented until the 1920s and wasn't really used until the Second

World War. All this development was really responsible for having reliable energy like Carnot said. And that's led to this population explosion. So we're dealing with a situation that effectively we're taken off, we got this huge population. And our logic right now is, let's get rid of it. But realize we're in a different state, we're not 600 million people anymore. We've never lived off anything but fossil fuels. And now we're quickly saying let's jettison the fossil fuels. And there is a good side to that, you know, we're going to certainly land a little bit sooner. But there's an enormous risk associated with that. Let's just take a look at it for a minute power when we want it. And this, I'm just going to go through historically, just what's happened recently, in the last four years or so 2018, there was a crisis in the UK, which is strongly dependent on wind power. And you can see what happens it's sometimes 25% of their power comes from wind other times almost nothing in two weeks, you can go from 25% to nothing that is catastrophic for any utility. If you told a utility in the past, I'm going to supply you with a power source that sometimes gives you 25%, sometimes nothing, they would laugh at you. But that's what we're banking our future on. Then we go on to the next year and ERCOT had a situation where of course, the demand was basically going to outpace the supply. And of course, what that did is that that's 200 fold increase in the cost of electricity to try to avoid that problem. Okay, we can skip talking about the crisis in Texas in 2021, in terms of the winter, but a similar situation. So how do countries like Denmark deal with this? Because Denmark it's 50% of your present electricity? So we say, well, look, there's examples that we hold out these examples to show we can do it. So let's take a look at Denmark, it's got the most wind. So here we go, here's March. This right here is the load. And lo and behold, they're producing much more wind than they needed. They can claim we were 100% renewables. Of course, then if you look a little bit later in the year, in August, it's down to here. So what are they doing? Here's the load roughly the same, and they don't have any wind. So what do they do? Well, they basically import. So they import when they don't have it, they import it. Okay, how do they import it? Well, let's look at Denmark. Denmark's demand is negligible. It's a small population. It's surrounded by countries that have a very high amount of electricity production, so they can supply Denmark with its deficiency without really blinking an eye during good times. So that sounds like a great strategy for Denmark. Is it in any way transportable to any other countries? No. Now don't tell California that. Because what does California do? California is dependent upon its neighbors for 25% of its electricity that allows it to keep its carbon footprint down, right, the carbon is in some other state. But the end result was it led to blackouts in 2020 the next year. And of course, the root cause analysis showed that the problem was, despite the fact that we know that wind and solar are not reliable, we went ahead and continued to build out and planning to not keep pace to lead to sufficient sources that could be relied upon. So we're aware of that. What we act on is another story, but we are aware of it. And then I put this slide up, I speak a lot since I've got a consortium called Wash U. You know, I have to justify our existence a lot. So I spent a lot of time writing slides and talking. But this came out last year. I want to put out that last year, so I'm not picking things from the past. This is what we were talking about last year. And this is talking about the crisis in Europe in 2020. Look at this situation. Remember I showed you the chart on wind production in the EU? Well, the EU British official numbers for their wind turbines were "Don't worry. There will never be more than seven days a year where our output from wind will be less than 10% of capacity." That was the understanding when they built those things. Well, unfortunately, 2021 there were over 65 days, sometimes 65 days where basically they can't rely on wind at all. Well, what did that do? Well, what is the backup for wind? We said

it's natural gas. So when all of a sudden you have a huge loss of one resource, you have to get another one. You haven't been supplying that or purchasing that so the price skyrockets. And so what happened, of course, is that natural gas prices skyrocketed. And we know that at that time, there was panic in Europe. And of course, the Nord Stream 2, was pushed to be certified. So that was what happened in 2021. Ah, did that have an impact? Well, let's take a look. Because this to me is one of the most important things. Why ask the question about having some type of independent department that deals with this, because public opinion right now and changing public opinion. I do not know how to do that without crisis after crisis after crisis. I can't see a way that it's solved. And you can see this right here. This person's already been quoted before, the deputy Economy Minister in Germany and Germany we heard made some major decisions. They put them in a very vulnerable spot right now. His conclusion is, despite the fact that what we have done is effectively made ourselves totally dependent on natural gas. He says we can't influence the world price of coal, gas, and oil.

So to me that's, you know, just there's this perspective that we don't think we should go for overly hasty measures which actually lead to higher prices in the long term or actually undermine climate objectives. So that type of logic is the thing that we're up against. Because really, the public is hearing this and believing that we need to stay the course. And of course, what happened then is as we move further in the year, you know, these are just some headlines last week winds worsen Europe's Power Crunch, because you just had very poor wind so that natural gas prices went up. Reserves went down, Gazprom refused to sell natural gas, to revive those reserves. And of course, you know, in February, Russia invaded Ukraine, I expect not coincidentally. So a couple of takeaway points. The EU and the US have been pushing the mantra that coal is dead. Okay, so first of all, that is obviously not the case, I just want to show one side of this. This is coal consumption. So this is yearly, this is from 2000, to 2024, with some projections from the IEA doesn't look particularly dead to me. In fact what's really interesting is, you know, the United States has had, you know, a role in coal, say, the last 10 years. The United States and Europe are minor players in this. Remember, now, this is China's of course the largest player, there's not just electricity, it's you know, it's manufacturing, it's heating, and India and the rest of Asia. So basically, Asia is everything when it comes to coal. And that's a really important point, because Asia is going to be continuing to use coal, because coal is abundant, it's there they have it, it's security. For them. It's cheap, secure energy, we're not going to wean them from that, we're going to force them to do something different. So really, if we want them to do something different, we have to be able to supply technologies that will allow them to potentially use that coal, but use in a way that doesn't affect the environment. So if we can develop technologies that use coal, but use coal with low emissions, then we have a potential allowing China and India and the rest of Asia to use this valuable resource without potentially negatively influencing the environment. So we have a leadership role that we play in this area, we have to recognize that coal is not dead, and it won't be dead in the foreseeable future. But another thing that happens now is when you make that statement that coal is dead, what you're doing is telling miners "don't invest in the future." So we're saying so that really isn't true. But its impact is leading to no development. And it's leading to no development. What happens well now you have a war, you have some upset, and now people are grasping for coal, because natural gas prices are high. But you don't have that resource, because you told people we don't need it. Right. This is a great statement that was made by Ethan Zindler. He said "to say in the long run, there is no demand for your product. But in the short run, can you please ramp it up?" You know, it's not to ask the supply chain. And another issue this does

is that when we have this attitude, it basically destroys investment in clean coal technologies, which China and Asia could be utilizing, and still be able to use their resources but do it in a way that's clean. So this, to me, is a really devastating attitude that we have right now. Just the last point, this is sort of interesting is how this is backfiring. Europe is now paying top dollar for coal, because they have it it's cheaper than natural gas. And it's available, you can ship coal easily. You don't need the regasification facilities that are very expensive. They have to have a pipeline associated with them. Coal is not, any train rails can take it around. It's an ideal fuel for these type of situations. You can easily get it, you can easily transport it, and you can easily store it on site. That's what makes it a secure fuel. Right. But we haven't done that. And so now what we're saying is that they are paying top dollar to get it. You know, the countries like Pakistan, Sri Lanka and Bangladesh can't afford it anymore. So what happened here in this way to try to do something valuable for the world is that European nations shun coal because they thought they didn't need it. Now they effectively have taken coal out of the hands of the poor because they need it. That's what's happening literally as we speak. But if instead the EU and US have the vision that if we burn coal, then we need to do this responsibly with minimal emissions. That's the statement right? A legitimate statement that would solve our emissions issues, then the coal supply chain would be steady as it has been over the last century and more, and the world would be a safer place. So the bottom line is the foundation, in my view, of a secure electrical grid is to have a source of clean energy that you can store, that you can rely on, and as Carnot said, is there when you want it and where you want it. And of course, to diversify the energy mix.

Massey: Well, thank you, panelists, there's many good points there that we can use to explore. As you can see, we have a variety of expertise from our panelists, and we're going to use their specific expertise to drive the beginning of this conversation. And so with that said, I'll go ahead and skip down to a question I had that directly addressed the issue of coal and kind of built off of some of the points that you made Rich. And that is we know, and as your presentation also showed us that coal remains a global resource. Globally, there's more than 2 million megawatts of coal fired electricity. And currently, there's another 184,000 megawatts under construction. Now, of course, we know that the challenge that we face with coal has to do with carbon emissions, or at least that's how it's been framed. And I also think it's interesting, the comment that you made about distinguishing emissions from the actual fuel source, something we'll explore later. But for this question, what I'd like to hear more on is how and to what extent do you believe opportunities exist for coal to play a role in a low carbon future? Yeah, let's start with you. Rich, I think you're a natural.

Axelbaum: Well, one of the things that I think is important, because we're looking strategically as to where is the role of coal? That's what we have to think about a lot. And we're aiming at a moving target. So what is that target going to be when we have technologies that are ready to be deployed? And really, the key point that we have to realize is that we are putting a lot of wind and solar on the grid. And that's going to happen, because what's happening right now, is it going to change that, not quickly, at least. So the future grid is going to have a lot of wind and solar. And so I think, as John pointed out, you know, natural gas has the ability to cycle up and down. That's going to be critical, because when the wind isn't blowing, you're going to have to ramp up when it is you've got to ramp down. So that ability to ramp up and down is essential. So we're saying for the future of coal is that it has to be able to ramp up and down, which it traditionally doesn't. And traditionally, it was baseload. And it has to be low carbon, or carbon

negative. So there are technologies like that. Our technology, that's what we're working on. We're working on technologies that specifically do that. So there, there's the capability for coal to do it. It's rethinking how you use coal. But the potential to do that exists. And they're not just early stage, they're pretty advanced technologies, that, in fact, can allow us to implement coal in a way that really doesn't just supply baseload power, that's not good enough anymore, it has to supply the power that can be ramped up and down at low cost. And another thing it has to do is have some level of storage. Because what happens right now is because of as you've seen, just the fluctuations in power, there are critical—it's a different area, if you think about what happened in the past with baseload power, you said, our plants are going to run 85% of the time, we're going to make this amount of money, and it was the trench almost like a commodity type of way of thinking about things. It's this stable, it's a little margin, I make a living. Now, it's completely different. Now. It's like, I'm going to capitalize on that moment that I can make a lot of money. And most of the times, I might lose money, but I'm going to make money a certain time. So the new power plants of the future have to say, oh, there's no wind, there's no solar, just like in Texas that what is 100 times more for my power, I can give you that power. So these new plants have the ability to do that. They have internal storage that they can say, Okay, you need more power, and I can send it to you. So if you can match the coal plants with the need, then you have a big future. Now, there's a big question with the existing plants because as you saw it, China, India, those plants don't have capture on them. It's going to be a big challenge to expect them to change that. But from at least strategically looking forward, we can have the next generation of these plants able to be low carbon. And again, one of the things about coal, unlike natural gas, is we can say we have a carbon capture plant. It's basically down to a negligible amount of carbon emissions. If I burn biomass in that plant, I can burn biomass in that plant. Once I do that it becomes negative. So the coal plant with carbon capture is really the only technology that produces power with negative emissions. And so right now, there's a big issue of how do we reduce previous emissions? Well a coal plant well designed has to do that. So there's a very bright future. But the problem is with the attitude right now, there's really not a push toward that direction. And the technology developments slow down. It's a critical time that I feel we need to try to ramp it back up.

Harju: I would completely agree. I mean, from the technological standpoint, this is extremely doable. In fact, all the technology exists today. It's about attitude. One of the big policy measures that we have to combat in order to try to ensure that as Richard suggested, we've, especially in the last couple of years, decided we're going to starve the R&D machines, we're going to start the demonstration projects. And a more insidious one is we're going to use ESG as a measure from our lenders, to starve capital, to mining and fossil fuel development, and it's a, you know, just an absolutely insidious thing that's underway, there's, you know, very huge challenges with it, you know, to sort of double down on that, the need for coal in our mix, I mean, look at the gas prices, that the roller coaster, just in the last 20 years, sometimes under $1, a million BTUs, sometimes as high as $14, a million BTUs in this country. I think back to, you know, great quote by then US Secretary of Energy Bodman "using natural gas to generate electricity is like washing your dishes with fine scotch." That's a US Secretary of Energy within the last two decades, yet, it's today the dominant means of generating power, while we have huge coal reserves in this country, that are low cost, and that have essentially seen other than on the export markets, no change in price. And in fact, at an inflation adjusted price, it's lower today than it was 20 years ago. So absolutely coal, you know, coal ought to be a huge part of our energy future.

Massey: Yeah, so those challenges being a combination of really market dynamics and the social perception that you've spoken about. Valerie, would you like to add something?

Thomas: So a couple points, one, on attitude. Another area where there's an attitude is the potential to use biomass. For energy. You talked about biomass energy with carbon capture and storage. And, you know, yeah, there are reasons you don't want to mow down the forest for energy. But we have in Georgia, for example. And in other places, really, a lot of biomass that can be used for energy can be used in the same facilities that are using coal, and we can capture it and store it. And so I think we need some more thought about that. That can be a green solution. It's okay, occasionally to cut down a tree, then to come back to the coal. I've been working a lot with some companies that are, you know, either capturing carbon dioxide, possibly to grow cyanobacteria and make biofuel and all this stuff. Okay. So we look around the country and the world. Where are we going to get our carbon dioxide because we need to grow our algae, we need carbon dioxide. So the first thought you would have is, we're going to go and set up shop right next to your coal plant. But then the problem is, yes, we're going to go sit next to your coal plant, and we're going to build a big facility. So that's a little bit of a problem. But there are a couple of coal plants that will still be excited to have a big place next to it. And we want to be producing there for at least 30 years. That's where there's a real challenge if there's not assurance, if there's not the reliability. These coal plants are going to stay open, then you just can't do anything with that carbon. But there's a lot of potential of just thinking about longer term industrial transformation and the role of coal in that.

Massey: Yeah, so Valerie, that's an interesting point in terms of thinking about our resources, or the variety of fuels that we can choose from, and not looking at them in a compartmentalized fashion, but how they complement one another. And I think that definitely demonstrates an area where they do complement that's not part of a bigger conversation. During this conversation, we mentioned baseload power. And so one of the things that we've seen is a shift in baseload resources away from coal, in favor of more natural gas, which we've already spoken about a little bit here. Now, we know that the opportunity that's driving this shift is a reduction in our emissions and price. What often gets less attention, though, is some of the challenges or the trade offs of that shift within the resources we're using to produce our baseload power. So let's see if we can explore perhaps some more of those. What are some of the challenges or the concerns associated with the shift that we've mentioned about from coal to greater natural gas for our baseload? Valerie, do you have anything, would you like to start with this one or?

Thomas: I haven't learned many things, working for a long time on energy. But one thing I've learned is that whatever I thought was true, is going to be false in about five years. So we've seen this, we've seen this with natural gas, natural gas, you know, first of all, I used to teach that we had maxed out on our natural gas, and it was going to go down. Same thing with petroleum, and that was clearly false. So now we have cheap natural gas. Well, we did last month, we have cheap, natural gas. And I would say the reason I believe that these coal plants are shutting down is the cost. It's just they're more expensive, we can do it cheaper with natural gas. So however, we've gone through cycles of this. We've gone through cycles of this United States and other countries. So we don't have a good mechanism for smoothing out our industrial and energy strategy over decades.

Harju: I know we have a PSC commissioner in the audience, and I gave you a quote from one of North Dakota's PSC commissioners "we'll approve a coal plant tomorrow. We only approve

applications that come to us." So I mean, the utilities are not bringing coal forward. And whether that's because of cost, or whether that's because of perceptions. That cost is going to be a huge driver. At some point. I mean, these are I mean, these are big, big, big questions. And, of course, these are very, very expensive facilities, right? So we're working with two of the larger utilities in our state. Nominal price tag for a carbon capture facility on a 40 year old plant, 500 megawatt plant, somewhere between one and $1.4 billion on a 40 year old facility with a net present value of less than $1 billion. Right. So when these are giant decisions, you know, affect the ratepayers and so on. And, you know, the PSC, or PUC's or whatever they are around the country will have a big, big stake in that. But again, lenders, they're also very averse to putting down any kind of capital into those sorts of projects. So I also think that because of globalization, on gas supply, and I see that getting worse as opposed to better or greater, as opposed to lesser maybe is the better way to state it. I don't want to put a value proposition on it. But I think globalization of gas supplies is a trend that is going to continue. I mean, up until 2012 we were an island. North America was an absolute island of natural gas production. Now we're one of the largest exporters in the world. And that was going to lift those prices. Especially when we see the energy security challenges of today.

Axelbaum: I very much agree with what John is saying, and I think that, if you look historically, at the price of natural gas, it was always fluctuating. And then there was sort of a sense that, oh, we have this new supply. So no more fluctuations. But somehow we forgot, Economics 101 that more supply can lead to more demand and that we pushed the world away. And if we push China away from coal, we're forcing others to use natural gas or encouraging others to use natural gas. So of course, now the supply is very large. This is not a surprise, why is it large? Because we pushed it to be large. And so now we end up having the fluctuations in natural gas price that we traditionally have. So what we did is we did make decisions on saying natural gas was less expensive than coal marginally less expensive than coal. And often when we're looking at it, just from that perspective, a marginal decrease in waste, they'll say, okay, that's abandoned coal, because it's marginally more expensive. But strategically, you know, what traditionally, diversity says that we have to have those because fluctuations are going to be sometimes it's more, sometimes it's less. So somehow, we have to build a structure that's more strategic thinking in this area. And, you know, as long as we are not doing that, we're going to continue to have these fluctuations. And this lack of reliability. I think that what I see right now is another factor, though. And, and this I think, is very important. I don't know how to address it. I've talked at EPRI and I've talked on the National Coal Council. And what I've seen is that those CEOs of utilities, those people that really have the knowledge to understand these issues, are not speaking up. You know, we're tenured faculty. That's a pretty important statement. You know, so I can say that, of course, I have biased interest. But you know, quite frankly, historically, I wasn't involved in coal at all, I had a startup company that I sold then, and I said, Okay, I'm going to think about what's really going to be important in the future and that analysis led me to believe I needed to deal with coal and make it clean. So it wasn't like I had a vested interest, it just made logical sense to do that. But having that ability to speak my mind is something that you don't have as a co CEO right now ultimately, if you don't say what the public wants you to say you will not continue to have that position. So imagine that. So we can't make decisions, critical decisions that are strategically appropriate for our public. I don't know how to address that. But I see that as a major challenge right now.

Massey: Yeah and Rich that makes me think back to the previous conversation that we had where we spoke about the players in decision making, and exactly where does that fall among—whether it be the government or industry or the company or the utility? And so thinking through what are the roles and responsibilities? And how do those various actors work together? And where should those obligations and responsibilities fall? Seems to be one of the more important points coming from this. So far, we've been focused on specific resources. So let's look at technologies a little bit. And one technology that's getting much emphasis right now is direct air capture. And so I was just curious to hear what are your views in the terms of the challenges and the opportunities that are associated with direct air capture, John?

Harju: So my team leads a consortium of about 200 companies focused on carbon capture and storage. Most of the projects that we're looking at small ones would be 100,000 tonnes a year big ones, 10 million tonnes a year. Those are all direct capture at point sources. Today's biggest direct air capture facility demonstration scale is 5,000 tonnes a year so you need to scale up by 20 fold to get to the smallest ones we tend to look at. And hundreds of times to get to what we would consider a meaningful scale that might move the needle. Also, somewhat energy intensive. Depending on what the end game for the captured carbon might be, you know, there's the subtraction of, well, we can do it anywhere. Alright, so we don't need to be near storage, but if you want to store it, you actually do need to be near storage. So you really can't do it anywhere. Or if you want to create products, which is actually another interesting concept that you can get to; you could create building materials, create fuels, you can create a lot of things, but they're very, very expensive. And again, the matter of scale, you know, that we need to get to is, this is very, very nascent technology today.

Thomas: I've been working with one of the companies that does direct air capture. And so yes, you can capture carbon dioxide directly from the air. But then you got it on your stuff, like you got it with Velcro, but then you have got to pop the carbon dioxide off of there. Okay, that needs energy. And it would be super great. If, in capturing this carbon dioxide, we emitted less CO2 from the energy we used than the CO2 we're capturing. So we're working on that. And one way is, so some of these technologies like global thermostat, they need heat, you heat it up to get the CO2 off of there. And it doesn't have to be super high quality heat, but you need a lot of heat. So really important. And you'll see this in a lot of technologies are any kind of heat sources, we have, like waste heat from a nuclear power reactor, waste heat from a coal plant, waste heat from anything, you have waste heat from a subway system, we really need that. And yeah, carbon capture from air, making it cheaper than a whole bunch of other crazy things you could do is a significant challenge. So we should definitely keep working on it.

Axelbaum: So what we're talking about right now is looking at how we capture carbon from power plants. It could have been if the power plant were capturing somewhere else or we could capture at the source. As a chemical engineer, if somebody asked me, okay, I have the ability to capture something, when there's 15,000 parts of that, versus 400. No chemical engineer would even think twice about it. Separation is very expensive. And the lower the concentration that costs of separation skyrocket. That's what's happening, right? If you're at the source, it's 15,000. If you're in the air, it's 400. And so what's the implication of that? The cost of direct air capture right now is at least say $400 a tonne. Okay? Existing carbon capture technologies, second generation carbon capture technologies that are available are 40. It's 1/10. The price, DOE's

goal is to get direct air capture somehow down to 100. So if DOE is able to do the impossible, and get it down to 100, there's still technologies out there that are much less expensive than that. What's very interesting, and this goes back to something that is a, you know where's the support for something as ludicrous as this, if you ask and you know where it comes from, actually enough, it comes from companies, because companies have to be able to say that they're net zero. And so they're willing to invest and pay enormous amounts of money to capture CO2 to be able to tell their customers well, we've reached net zero. And they wouldn't be willing to do it through a carbon capture on site because then they'd be supporting the coal industry's efforts as well. So we're in a very unusual situation right now. Because it really, there's going to be a huge, enormous amount of money spent that's in my mind, never going to really go anywhere. It's a distraction from really doing something that's really substantial and meaningful. So that's my sort of summary on direct air capture.

Massey: Well great, well, in an effort to make sure that we keep the conference on schedule, what I'm going to do is ask one final question, and then we will open up the floor for questions. But what I'd like to hear is kind of as the last question we have, I guess for me to pose is transitioning to a lower carbon future is going to require many emerging technologies. And so we've discussed some of those. But could you just give us kind of as a parting shot here, kind of your top two or three emerging technologies that you think are what's most important for us to focus on? And then we'll open up the floor to questions. Rich do you want to start?

Axelbaum: Well, I think our technologies try to address the specific needs. And it's, you know, I think one of the key things, you know, just with respect to coal, just the ability to store it on site and transport and all those types of logistic issues are so important that I think still, we need to have coal as a major part of the mix. So we need technologies that are coal related, and this technology happens to be just fitting very well. It's well supported. But I think there's another for natural gas is the Allam cycle, which is super good, a direct supercritical cycle, which is a very efficient cycle that can capture their cycle works based on combusting natural gas with oxygen. So the product of that is just CO2 and water. Ours is similar. We combust coal with oxygen. So it's basically CO2 and water is the product. So you have a method of doing that. There is a direct air capture that are more efficient, actually, than a process when you're using natural gas versus more efficient when using coal. So I think those two things are sort of solid baseload and also flexible technologies, I think would be very important for the future. I mean, realistically, in terms of any success with wind and solar is going to be based on long term seasonal storage, it's more than seasonal as we see right now. It's disruptive storage to our seasonal storage, assumes everything in the world is going to go just our way. It's just sometimes it's going to be summer, sometimes it's winter. But that's not it. It's up sometimes somewhere at some point we're in sometimes Russia invades Ukraine. So we really need something more resilient than that. But I think at a minimum, we need to have some type of long term storage, that can say that the wind and solar are viable, long term, I think the biggest thing that I tell students, I say, you know, if in fact, wind and solar and storage were viable, then please somebody tell me the state that does that. The city that does that, the town that does that, show me some place where they disconnected from the grid, and they work off solar, wind and batteries, because that's what we're saying, without any proof anywhere in the whole world, that they can do that. We're saying we're going to transition the world to that. And so it's never happened.

Harju: I've actually been to that place it's right along the Mexican Belize border and what they wouldn't give for a power line. Yeah, I mean, I've got a bank of batteries and a windmill and a solar terminal. And you're absolutely precluded from using a hairdryer, and, you know, all of these other things that they adapt to. So I mean, it's really to support your point as opposed to, as opposed to arguing. I actually think nuclear is technology that's just so important. And it's unfortunate that we've run so far from it. And, again, clean coal, carbon capture and storage, are really just a big plug. How does any of this work without the infrastructure to connect it in, you know, think of my paradigm earlier, you know, bad information leads to bad policy, and how naive our policymakers are about the condition of our grid today. And the inability to even consistently deliver from our supply to our points of demand. We have a big project with a company looking to bring about 10 million tonnes of CO2 annually to a storage facility in North Dakota. And everywhere along that pipeline route. They've got problems, that's a CO2 pipeline. Imagine, you know, how bad things are going to get in the Northeast because they're so proximal to that incredible world class Marcellus gas resource, but no new pipelines. No, we're not going to have any of those new pipelines. I mean, that this notion that infrastructure, you know, is something that we don't need is so ludicrous. And you know, I mean, I'm surprised we haven't noted the number of people that died in Texas last winter. I mean, it wasn't just people out of power, a whole bunch of people died, because of, you know, early retirement of fossil fuel, because of over reliance on renewables, because of an energy authority, shutting off electricity to the pumps that would move water and gas that might have surprised the backup. I mean, it's so ludicrous. I mean, it's like we've turned back the clock 100 years in this country to when we were, you know, eking out our meager existence, you know, burning wood in our households and not having, you know, convenient, reliable electricity.

Thomas: I'm not sure if I'm agreeing or disagreeing with you. So let me just let me just try to disagree, right, this isn't fun if we don't do some of this. So it's not because we've gone away from fossil fuels. It's not because we have too much wind and solar. It is because we have a really stupid old fashioned electric grid. And so my vote for the most important technology focus is to have an agile and deeply resilient electricity system at very refined spatial and temporal scales. We need to have situations when people can be disconnected from the broader grid, and do just fine, thank you very much. And there's no reason we can't do that today. So we need to just think much more freshly about what electricity can be, and who is in control who understands it. And to have that be as great as our other industries in the United States are like, you know, the internet and stuff like that.

Massey: Yeah Valerie I think about the first slides that you had referenced and some of those technologies. Rich, you had one last point to make.

Axelbaum: I think it's sort of fun when we disagree. So you know, one of the things I have a slide for on this, I'm sorry, I didn't show it, but one of the things is really dangerous. And that is when I, for example, sometimes we say, well, batteries, and bear with me, I gotta give a dynamic, and I had the slide would show up, I think you'll get it. Our country has basically enough power right now, barely. If we didn't have any wind and solar, we'd be fine. Why? Because before we had wind and solar, we built a system that didn't need wind and solar. So the fact that we have wind and solar going up and down doesn't matter to us, because we already have enough power with them or without them. Okay. And we always have a reserve. So now what happens, you know, we have wind, we don't have wind. Okay, so you increase the baseload

power, you don't have a problem. But what happens, the more wind and solar you put on the system, the less often you use those power plants. So we all know, economics 101, if my plant's not used as much, I can't afford it. So yes, plants are closing because it's not being used that often. So that's going to happen. So what happens when the plant closes? Well, you used to have that reserve that was saving the day when wind and solar weren't there, you just lost that reserve. Right? Understand that concept. So now, you know, I think you're thinking things are good, because you're closing down these plants, but what you're forgetting is I'm closing down those things that were making solar and wind look good. And the more you do that, and the more you stay on that path and push that path, the more of those plants are going to be closing down. Okay? Now, what happens is, the more solar and wind you put on the system, the more fluctuations there are, so the more you need those plants, because you have huge swings. Now you didn't have when you had a small amount of wind and solar. So what happens is, the longer we delay, for example, like if we put infrastructure in so we can get power from different places. That makes us feel like "good, we're safe from the weather." And so we can close more plants down. But the reality is the weather is the weather and this year it may be behaving, but next year it's not. And the further we push this attitude, "I'll add some batteries I'll add some infrastructure, and that will preserve us from the weather." The more are baseload plants that are saving us are going to be retired. And that is what I worry about right now. I worry where we stay on a path that we keep trying to patch this thing. So that we can take these plants offline. And then the weather is going to hit just like it hit in Europe, the weather hitting Europe, a low wind. Oh, what happened? Well, wind, oh we got to use up our natural gas resources we're vulnerable to Russia now. Well, what can what can Europe do now, because they've retired their coal plants and their nuclear plants. They're completely dependent upon Russia right now. So the perspective that somehow we're going to weave our way out of the reality that wind and solar are not reliable. The weather pattern in the United States can be a broad weather pattern that affects everybody in very much the same way. We can't average ourselves out of this problem. We average it out enough, that allows us to move further down the road and retire more plants until it is hit with a big weather pattern, then it's too late.

Massey: This is an interesting discussion. And Valerie, if you don't mind in the interest of opening up to the audience, I'm going to give Rich the last comment there. And so now, we've got a few minutes left, where we have an opportunity to ask a few questions from the audience. And so Shannon.

Shannon Stevenson: Dr. Thomas, I agree with your opening slides looking at kind of micro level planning in the residential and commercial sectors, looking at ways to increase energy efficiency, such as, for example, the idea of prioritizing kind of thermal insulation and households. However, I fear the question of equity of these programs, as in the communities such as those that experienced systemic poverty, or expanding into lower income or even median income given the state of the current economy. Those communities that would stand to benefit the most from not only internal dollar savings over time, but also externally in contributions to reducing energy consumption are at the same time the most discouraged from engaging in these programs in the first place. And I refer to the example of the LED light bulbs and the proverbial Terry Pratchett economics of the boot analogy, where LED light bulbs consume three fourths less electricity per day than halogen bulbs and require less maintenance. So somebody using these

bulbs over time not only consumes less electricity, but also puts less dollar value into operating lights. However, the upfront cost of these is higher than that upfront cost is either inaccessible to the lower income communities, or simply discouraging from purchasing these in the first place. How can we institute these kinds of programs without falling for the Terry Pratchett boot proverbial pitfall in the future?

Thomas: Okay, I'm supposed to answer the question. Thank you very much. This question of poor people having high energy bills that even they can't afford to pay is, I think, a fundamental challenge for energy policy and energy security. If there's going to be government funds paying for repairing the energy system, I think that one is a pretty good candidate. And it's also not simple. It's not just let's go run around to everybody's trailer and add insulation. So there's a lot of helping people understand, you know, how can we save money? I think we should take a higher level approach. And how about some smart meters there? How about some, you know, AI, in the trailers and not just in the big fancy condos in Atlanta. So I think a lot more attention to that, rather than just thinking this is too hard a problem, or it's going to be expensive, is worth doing because addressing the people who are most vulnerable to high prices or a power shutdown will help them a lot, and it will help our country and these other countries.

Massey: Okay, Dan, you have a question.

Dan Doss: Yeah, so this is mostly for all three of you. But this is for all three of you, but mostly for Dr. Axelbaum. So I want to start by saying I agree that renewables are not viable right now, especially battery technology is not anywhere near where it needs to be to function on an even state-wide scale. But I think coal seems viable because we've used it for so long. And because of the reasons you've talked about being able to store it, transport it, and it burns like a traditional fossil fuel. But one day, we don't know, we don't really know when it's going to be it's going to run out because the current estimates are 90 years. But just like all the other systems that keeps changing as we find new ways to extract as we find new sources, but one day, we're not going to have coal anymore. So what is your reasoning for spending the money on coal now, on making coal more usable now? Instead of using technologies that don't have some end date on? Like, what's the reasoning that when you went through your analysis, why did you decide on coal, instead of investing in technologies without an end date on them?

Axelbaum: For my career in hydro then move to solar, and then decided that wasn't going to necessarily be as meaningful and impactful as dealing with fossil fuels because we combust 90% of our energy 80% from fossil fuels. So it's just having more impact on things. One thing to keep in mind, I have a colleague who wrote a book, and it's a good line, and it's talking about there was a economics professor. And he says, Okay, we have 100, something of fossil fuels, right. And we use 10 a year. Right now we're using 10 a year, we've got 100. Okay, now calculate, when are we going to run out of fossil fuels? And most people could do the math. What was the answer? Never. If you don't understand that, you don't understand economics, you never get around on fossil fuels. Doesn't make sense, because you're going to reduce them, the price will get higher, there'll be less use, and it's a natural process that occurs. And that's what's going to happen. The numbers for how much coal we have, were based largely that 80 or 90 years was based on coal use of the past, as we reduce it, if coal is only 10% of our energy, it's as an enormous benefit from a strategic stability perspective. And it can last quite a long time, hundreds of years. So I don't worry about running out of coal. If we can fix the problem as we think we can with the next 20 years, we'll be have plenty of time to fix the problem in 50 or

100 years if we were running out of coal, so I don't see the running out of coal, when it's so far in the distance that, you know, it's irrelevant to us to harvest that as a reason not to address the problem right now. And I don't personally see that we're going to be running out of coal in any significant way for hundreds of years. Because the numbers the model that we use will be reduced but its intrinsic value will be substantial.

Harju: There was a guy I used to work with had a great had a great moniker was "Stone Age didn't end because we ran out of stones." Now and I mean, if you want something better, I look at the success of Tesla automobile. And I don't think it has anything to do with carbon. I think it has everything to do with its fabulous technology. These are fast. These are high performance. These are luxury automobiles that people want them. If something's better, the world will race to it. And it really to Richard's point and we have had incredible policy incentives to boost renewables for a long time. So I ended I went back to 2019 because these are the best, I think, data years for energy use and them mastic 2020 is, is really an aberration. And I don't think any of us really want to look at that as a picture of our future and how we're going to use energy. But you know, you know, the two sort of old standby renewable technologies, frankly, hydroelectric power, and wood burning are about the identical productive productivity of energy in this country as solar and wind combined. And that's after decades of intensive research of massive subsidies. That's where we're at. And I agree, continue to improve upon these technologies, make them better, because we will need them someday. In fact, we probably need them today. But they really need to do a more a better job at reliability. And whether that's via storage, or whatever it might be. I'm all for it, but not at the expense of what actually gets us through every day.

Massey: Valerie, do you have anything to add? Great, then we will let me get our last question. I think we have time for here on the floor, Bryce.

Brice Fincher: Hello, I would like to ask all of you all about what do you think about using carbon taxation or alternate forms of carbon pricing to either reduce carbon emissions, like, just reduce the demand of coal or natural gas, or wood, something like that incentivize these like carbon capture technologies? Or if there's other sort of like, kind of taxation mechanisms to incentivize changes, like the energy transition, like either, like taxing imports of rare earth elements from China, or taxing land value to incentivize like, reforestation to create carbon sinks. What are your, the panel's opinions on that? Well, we'll start off with carbon pricing, and we can go from there.

Harju: So I look at incentives and taxes really as two sides of the same coin. And which one is more effective? You know, I think it's an age-old debate. But we do have incentives in place for almost everything today, whether, you know, in the carbon management space, whether they're equal, but also debatable, but you're also seeing any major energy companies stepping out and saying, you know, what, just put a price on carbon. My customers tend to evade taxes more effectively than chase subsidies. You know, that's my own observation, not, you know, it's not been systematically and they're thoroughly, you know, dealt with, but people, you know, really, really hate taxes. That's what I see. So, you know, taxes are something that tends to get the attention of an emitter? Absolutely. And, you know, the American Petroleum Institute is actually, you know, right on the cusp of formally advocating for carbon taxes.

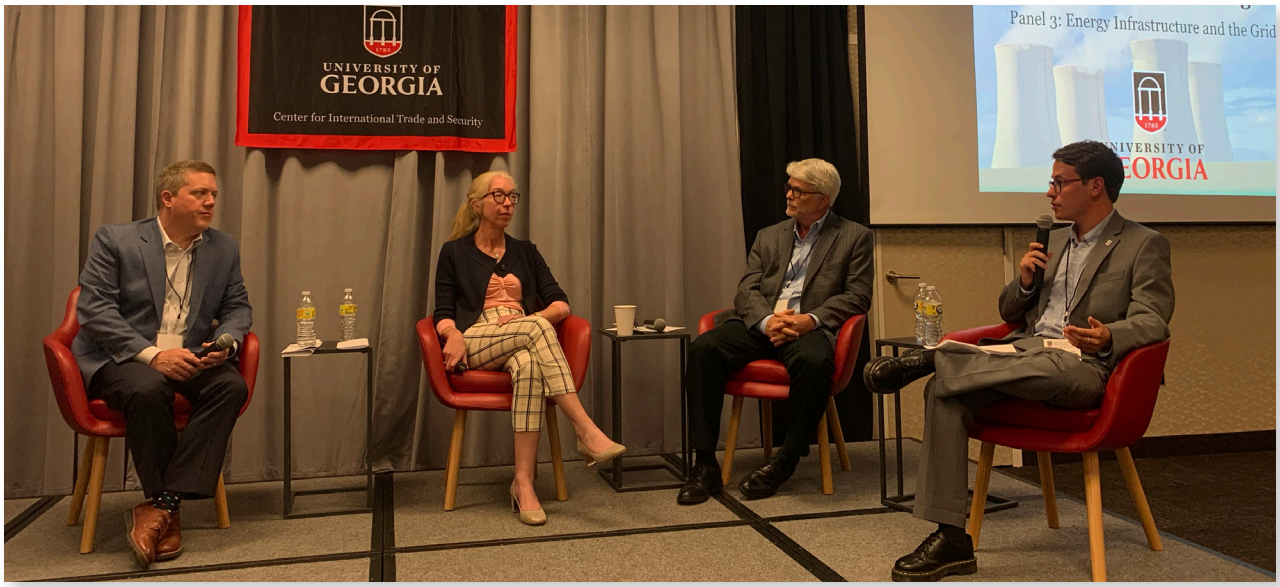
Thomas: Sure for carbon tax, if we're going to have a tax, if you compare it with subsidies, the advantage of the carbon taxes, it's not going to be even, I mean, it's not going to be pure, there's going to be stuff and side deals, but at least in theory, it kind of puts everybody on the same playing field, and it tells you how much we're paying for carbon. And on the other hand, it just seems not what our country does. You know, we have economically theoretically, that's the best thing to do. But instead, we have CAFE standards for efficiency of cars, and we have CO2 limits on electricity so that we have a hodgepodge. So I just, I don't know which way we're going to go.

Axelbaum: Yeah I'm not sure I have a strong position on this, I don't think I would be opposed to it. I think it's, as John says, you know, there's different approaches to it, which is really the best? I think along with it, though, if you're going which would be I would say more of a draconian type of approach where you're saying, "Well, this is really critical that we address CO2." Then at the same time, we have to say, Okay, well, we also have to make sure that we have a reliable grid. So if we're saying I'm going to address CO2 at the same time, ensuring reliable grid, and I think coupled with some type of CO2 tax would be something in the ISOs, or some system, that would say that you get a certain amount for selling electricity, if you can provide me that electricity whenever I want it. And if you can't provide me the electricity, whenever I want it, then you get this much. And if you can provide it, when I want it, you get that much. So if we were to put a carbon tax on, you see where I'm going with this, it has to be linked with the fact that your ability to supply the power when I want it is extremely valuable. If you think about anything we do in society, when I can rely on something, it's valuable to me. I can have an employee that's really bright but doesn't show up for work in critical times. And that person is fired, you know, so we know reliability is essential. And if we want to do something like that, which is the reason I'm saying that because once you do that, the problem is you are forcing people into a mode of going to unreliable electricity and so they have to be coupled or anything like that.

Massey: Well please join me in thanking our panel for their comments so we are going to break for lunch and I believe we reconvene looks like at 1:30. We'll ask the panelist if you would stick around. I believe we're going to have a lunch brought in for the panelists and so if you're on a panel today I believe there's lunch and for everyone else we'll reconvene here at 1:30 right? Thank you.

PANEL THREE

Energy Infrastructure and the Grid



Left to Right: Jeff Grubb, Laura Schepis, David Gattie, Chase Duncan

Chase Duncan: Right, thank you so much, Commissioner Echols. So as you can see, this panel is going to be talking about energy infrastructure in the grid. So in our last panel, we discussed some of the technologies that are going to be critical in the energy transition. And we're going to build upon that here and talk about the energy systems and infrastructure that is actually used in generating electricity that we use every day. So with me today, I've got a great group of experts from industry as well as UGA's Dr. Gattie from academia. So we have Mr. Jeff Grubb from Georgia Power. He is the director of resource policy and planning at Georgia Power and is responsible for the development of Georgia Power's integrated resource planning or IRP. Georgia's IRP was just filed, actually, in January, and Jeff has been the lead witness on those hearings. Miss Laura Schepis works for Jacksonville Electric Authority, and for three years prior was working for Edison Electric Institute as a national security advisor. And Dr. Gattie, you saw him before. He is an associate professor of engineering at UGA's College of Engineering, as well as a Senior Faculty Fellow at CITS. So with that, I just like to thank everyone for their time, and remind everyone of the ground rules. So this panel is going to last roughly an hour and a half. We're going to begin with some 10 minute or so presentations from our panelists. And then I'll begin to ask the panelists questions. And then finally we'll open it up to participation with the audience. So I just wanted to thank you all again for coming and thank our guests for being here and lending their expertise. So with that, I will give the floor to Mr. Jeff Grubb.

Jeff Grubb: Thank you, I appreciate the opportunity to be here as a Georgia Tech alumni and an Auburn alumni. This red and black is a little tough on me. But this is a great conference. In all seriousness, I did marry a Georgia girl. So I got that going for me. But now I appreciate the opportunity to be here, sitting on these two panels and listening to these panels this morning. I mean, I'm like What am I doing here? I'm just the state guy. Right? These huge global issues, these energy security issues, but I think this will be very helpful because and Commissioner Echols is here. This is where the rubber meets the road. This is where Georgia Power is making our decisions that is impacting what our customers have, and what does take place in the industry. So it's been, it's very exciting times, I just wanted to go over some of the IRP process in Georgia real quickly, kind of the progress we've made over the last decade or so at Georgia Power. And then some of the things that we've filed I mean, we really are right in the middle of this IRP, we had our first set of hearings, other parties to the case will present testimony next week, and then we will wrap everything up in June. So we are right in the middle of everything. So I'm assuming this. There we go.

So the integrated resource plan, what is it? Some of you may know, some of you may not. And this is from the viewpoint of our state-regulated vertically-integrated utility. So we're not an RTO. We're not an ISO. I think it's a market structure that works very well, you'll see that we've made good progress there. But what basically what the IRP is, it's our long term plan on the resources that we're going to have to meet our customers' needs. So obviously, we're looking at that from a reliability standpoint, we're looking at it from an economic standpoint. So a lot of that first part is just we've got to know what are our fuel projections? What are we thinking about carbon? We actually look at many different views of the future and weigh that in, because these are all long term decisions. What are your loads looking like? What technologies do you have available, it's about a 2,400 page filing, we had 10 and a half hours on just our panel on the first day of witnessing, if you want to go to sleep, go to YouTube, pull it up, listen to my summary. And, and you know, you'll fall asleep. But it is really a fascinating

process. And so what that second part is talking about is that the IRP is really vital. It's how we communicate what we're recommending. And that's the key, we recommend the plan to the Commission really shows the value of what we're looking at in terms of our customers. So if we're going to add a resource, we're going to retire a resource, we really get the value that brings our customers, and it's a very public arena, it's very transparent. And the other part of it is, is a vast array of stakeholders are able to take part in this process. So Georgia Power files are playing with the Commission. We have environmental stakeholders, we have industrial group stakeholders, we have solar developers, industrial groups, we have many, I think there's 17 different parties involved in the case that will also file testimony and take their positions on what the commission should ultimately rule on our plan. And then we'll get back up. And so it's a very robust process that takes six months, but it really is where a lot of the issues come to be discussed. And when at the end of the day, everybody's had their say, the Commission rules on the plan, and we move forward the implementation of it.

And so it's really a really exciting time to be in the IRP, one of the main parts of our IRP right now is really a fleet transition. We've had a lot of discussions this morning on these types of things. What we're looking at is that next step, we've retired call units over the last several years, we've added renewables. In this particular IRP, what we're looking at is requesting of the commission and again, to request of the commission of retiring around 3500 megawatts of coal over the next six, seven or eight years. One of the things that the latest environmental rule gives us is enough time that we can build out transmission without having to put up controls on some coal plants. If the requirement to control a coal plant is three to four years, and you need seven or eight years to build transmission, you really don't have any options. The effluent limitations guideline gives us enough time, if we want to transition out of a coal unit to build some transmission. And so that's what we've looked for. We're asking the commission to certify or accept the replacement generation from existing gas units. So we did a request for proposal coming out of the last IRP knowing that if we were going to retire some more of our coal units, we had to have megawatts to replace them. In the past load forecast reduced, we could retire coal units, we didn't necessarily have to immediately replace it. But there are existing coal units, we did opt for shorter term PPAs. As you've heard this morning, a lot of things are going on in the industry. Like, we felt like having a shorter term PPA gives us the chance in the mid-'30s to look our hand over to see what other options are there as opposed to doing longer contracts. And really, we got incredible deals on these resources, which enables us to retire the coal units and economically benefit customers.

Another part of the fleet transition is continuing to add renewables. So the prior part was really around reliability aspects. So we've got capacity-based coal resources that to the earlier discussion, we can dispatch, we can run—we're replacing those with natural gas, but renewables do bring energy value. So we're adding renewables for that energy value. We aren't looking at renewables as 100% counting on you to be able to serve peak load, it's an energy value, we model all these things. But we do see the benefit of continuing to add renewables, we see pricing in our PPAs, around $3, or $30 per megawatt hour, three cents or so. So it's a very economic energy resource. How do you continue to build that and add that? Right now we're committed to go to about 5,000 megawatts by 2024. So we're asking for another 2,300 by the end of 2030. But as we continue to add them, from a reliability standpoint, there's things we need to do, we need to add storage to be able to more reliably integrate it, and we need to have more control. The vast majority of our solar resources are through contracts, we don't

own most of it. So how do I get the ability to reduce that solar generation when I need it from a reliability standpoint? So we've proposed many aspects of that in the IRP.

And I hit on a little bit, but the other huge part of this whole fleet transition, that's really a longer term view than we've had in the past is transmission. We've always built transmission, for changes in load and changes in resources. But what we've looked at now is, as you continue to see pressure on coal units, as you continue to add renewables, the vast majority of all our renewables in Georgia have gone to South Georgia, it's flat farmland, it's the cheapest place to build solar, almost 90, something probably almost all of it is gone in the south. Where do all the people live in Georgia? It's not down there. So all the load is in the north half of the state I–20 and up. We have very little generation in the north when you compare it to the load. So those renewables, now as you start adding them, we've added enough, it's getting hard to actually have the transmission for that generation to get to the north. So we need to proactively look at that fleet. And say, look, if we're going to continue to add renewables, we want to be able to build them in South Georgia, need to build transmission to allow that. And then also the system–because we're integrated, and we look at generation and transmission, the transmission system was built around these big call units. So as you retire them, you have to have transmission solutions. And that's really driving our timing on our coal retirements. Even if we wanted to retire a certain coal unit in a few years, you can't because you have to build the transmission so that transmission is a huge part of this plan.

And so from an infrastructure standpoint, it's crucial. Gotta be able to build those to really give you that option to be able to make your decisions on the coal unit. So we've teed a lot of that up with the Commission. Again, we've got a lot to continue to go through. We got a few more months before that's finally resolved. But a lot of things around the fleet transition, we're looking at the coal fleet, and what are you going to do to replace it? A few other supply side issues on here real quickly, we talked reliability ERCOT came up earlier, we every three years in the IRP file our reliability study with a commission, where we look at hundreds of thousands of cases, what could go on the system in terms of you know, whether it's not going to be normal, your units are going to have different outages. So we study that, and recommend that reserve margin, that we want to make sure we have enough capacity resources to meet. We're also going to, we're asking to continue to invest in our hydro fleet. That is the original renewable and storage resources. And it's what the company was built on. So they're old. We've had a lot of years where we were able to maintain these units, but we really need to be able to go back in reinvest in the generation aspects of those hydro dams, because we see them being very vital resources, not only because they're carbon free and very flexible, but just think about their impact to the state, recreation, those types of things. So we got permission from the Commission, the last RP to invest in five, we're asking to do the next three. And that's about a decade long program to really keep those resources for the next 40 or 50 years. Nuclear has been discussed. So we have Plant Hatch, which is our original, our first two nuclear units, their licenses were extended into the mid '30s. We are asking the commission to allow us to go to the NRC and apply for a subsequent license renewal. So then we can then come back to the commission if we get that license and decide if we want to keep those units from the '30s into the '50s. We see a lot of value in that. There are existing nuclear resources. They're not new, they don't have to be built. So we're asking for that as well, because we see that being a very important resource as we move forward.

And then the next thing is technology advancements. So we're always in the IRP and looking at what's next. We've got a huge R&D effort at Southern Company, but for Georgia Power customers, what may we want to gain experience with, and what we asked the commission for, in some cases for early deployment or demonstration projects. We've got approval in the last IRP for several, 10 to about 80 megawatts of batteries, but what we're looking at now is tall wind, and hydrogen. So winds have been proven, that's not a new technology across the country. But in Georgia, our wind resources are at really, really high levels. So we did some studies, I think out of the 2013 IRP, I believe, where we studied with laser detection, what are the wind speeds, and it exponentially grows. So as you get more when your generation is greater, so we're not sure economically that the normal 120 hub height is going to be, you know, economic. But as we continue to add renewables, wind could complement solar very well. All of our reliability issues we see now or in the mornings in winter, wind may be available to help us with that. But you've got to have a really tall wind resource. And so we're not proving the turbines, we're proving the technology to build, but 160 meter tall windmills, which is spiral-weld technology that you actually build on site, the heights are limited by the fact that you can't transport the towers under bridges. It's funny how things are happening, but you can't get certain heights because you can't transfer from somewhere else.

Through the transportation systems, you can actually build spiral-weld, which has been used in pipeline construction for years, and get them up to 160 meters. So we're asking for approval to go do around six to eight megawatts of those to just see what that wind resource really is. And then we're also dipping our toe into hydrogen a little bit. We've requested for a hydrogen integrated micro grid, we've really been able to leverage some co funding from some other partners, DOE General Motors, where we can go do a little bit of electrolysis with hydrogen, we can use it to power a fuel cell, we can use it to charge EVs and we can also use it to charge hydrogen vehicles. And so just trying to get a little bit of experience with electrolysis, we've talked some about hydrogen, we see hydrogen potentially having value for those purposes, but also how does it help with natural gas? Can you blend it down the road so we can get experienced there. And then last thing, distributed energy resources, you know, centralized station has been the economic source in the industry for years, I think it still will stay as the most economic but it does have a lot of challenges, a lot more costly. You have to deploy a lot bigger megawatts. So demand distributed energy resources and moving away to a little less decentralized grid. What is that space going to look like? You have a lot of customers who want resiliency options, I want to have the resources there on my site. So we've proposed a program where we can build a resource for them to support their facility in terms of grid outage. But while it's there, we can also use it in reliability purposes to serve the whole fleet. And so we've got that proposed. And we also proposed some power delivery type project. So where I can't do certain wires solution on distribution, can I do a distributed energy resource to help me there? So a lot of technology in this IRP as well. We always have to balance the need to learn that with what does it cost customers. And so the whole IRP is about balance, between reliability economics, and we're always looking at clean, safe, affordable and reliable. We've got all four of those tenants that we have to balance.

And so we've found that with the Commission, you know, the IRP is really where all our decisions are made. If you look at the last several years, we use 2007. Because most of your carbon reduction goals are always stated in 2007 terms, but our fleet looked very much the same way in '07 up through about 2011 or so. But as you start looking at what we've done in the IRP

and how we've transitioned the fleet, you can see there's been quite a change from 2011 or so to 2022. And then also where we're projected to be in 2030. And so this is our capacity mix. So this is just megawatts on the ground, steel on the ground. So it's not how you generate from them. It's not what we plan on them from a reliability standpoint. But it's just how many megawatts we have. So the trends you can see that obviously pop out to you is the yellow part of it in 2007, so we had no renewables, not counting hydro, non hydro renewables. We've added a lot through 2022. Most of it is solar. Wind just hasn't competed against solar in our solicitations. If you look at the 2030. With what we've proposed in this RFP, we've given guidance that we think we should add around 6,000 megawatts by 2035. But this captures that request of 2,300. You get to be about 32% of megawatts on the ground, from solar and storage, nuclear is 13. You can see that nuclear is 11. As of now, so from a capacity standpoint, plant, Vogel doesn't look big, because it's about 1,000 megawatts for us. But I'm about to show you energy. And that's where you really get your impact there. But then the other part, you can see it's very telling is that red part. So we've done a lot of things on the coal side, we've converted some coal plants, we've retired some coal plants. If the plan that we've proposed is approved by the Commission, you're down to about 8% coal, it's really plant Bowen the main one left, and then that gray part is carbon free resources.

But I think the important point I would make on this graph is we did not do any of these just for carbon. We did it because adding solar has benefited customers economically, retiring our coal units has been in the best interest of customers, we've been able to do this move through the IRP and working with the Commission, because it's been economic for customers. If you look at energy, how you run on the megawatt hours, you can see that projected energy mix from coal, this year will be about 16%. Out to 2030. It's only around 3%, you have one or two call units left, if the plan is agreed to the gas and oil section that's really gas, the oil part is very, very small. We'll run oil on very critical reliability periods, but not usually any much more than that. And then that carbon free percentage you can see is growing from around 40% this year, to about 55% 2030. Vogel in our nuclear and our other nuclear plants are probably 30% or so of that carbon free energy, the rest being hydro, and our solar. So we've been able to make a lot of progress over the last several years. And looking forward in the next six or seven years on what our fleet looks like. The important part is we've been able to do it affordably and we've been able to do it reliably. And so as we continue to transition the fleet, whether it's adding solar or getting out of the coal units, you have to maintain that reliability because as we've talked about, it's so crucial for electricity use for our customers. So I just wanted to tee that up. We'll have some more questions. But from an infrastructure standpoint, lots of changes on our system, lots of interaction between generation and transmission that we're able to focus on and recommend to the commission. So looking forward to discussion, thank you.

Laura Schepis: Well, good afternoon, y'all. Thank you for giving me some time. I'm Laura Schepis with JEA we run the electric and the water and the wastewater system for Duvall County and some other counties in Northeast Florida. We're about on the electric side, maybe 10%, the size of Georgia Power. But we have a very diverse and unique community. It's diverse, in that we run from the beach to the Pineland North Florida area. We have my daughter who goes to high school with Tiger Woods son, but 40% of our population struggles to pay their electric and their water bill. Our energy mix. I don't have pie charts. Our energy mix doesn't look much different than Georgia power's and we are facing the same pressures that you've heard about all morning.

Gas prices used to be like this and now they're like this. One day soon we'll receive some power from Vogel. So we're getting into the nuclear business. We sit with our board in a very public fashion online on the internet eight times a year. And the public is absolutely welcome to all of our discussions. We're having a very public and open debate about how to transition and how to innovate and as our Georgia Tech professor said this morning, how to become agile and innovative and deliver the grid that the future demands. And we're also kind of midstream in an IRP. And that's why I was really delighted to get the chance to talk with Jeff today. I'm running our stakeholder process–25 citizens from the Sierra Club to one of the southeast largest aluminum smelters and recyclers. That's diversity. And so we're running that stakeholder process talking openly with them about how we deliver the energy future, to Duvall, which is growing quickly, it's amazing to me to see it on the same list as cities like Austin and Salt Lake and Denver.

So, I also talked at lunch, I had a delightful conversation with two professors here about how you have a plan and you have everything out on an Excel spreadsheet, and you're supposed to talk about, it's supposed to go to a certain school, or you're supposed to talk about a certain thing on the panel. And now David is looking at me, like, Where is she going? So, yeah, I will do what I said I would do and talk a little bit about an incredibly important grid security. It's not even a detail. It's not even a topic. It's a pillar of grid security. And that's how electric utilities manage cybersecurity, how we're regulated for it, and then what we think we need from our government partners and from our other stakeholders in order to continue doing a very great job with that. But I also want to spend my time back on the panel, trying to respond to all the different things that we've heard today, all these different threads that so many smart people have brought up the energy industrial base, the grid that we need, the ESG train that has left the station. So I hope to be quick about cyber, and then sit back down. And let us get on with discussing. So all right, I warned Josh and Chase that I'm really not good at slides. Here we go. You guys know that we have about 3,000 electric utilities in the country. And our grid is broken up into two big interconnects east and west and then ERCOT which is its own special place. We have vast differences among those 3,000 utilities, and it's 3,000 that distribute power to the home and business and send people a bill. But we also have some vast similarities, a lot of our supply chain for our software, and our hardware and the things that we use to make electrons and send them to people. There's a lot of similarity. There's a lot of single-source elements in our grids. So the differences in how we're run as a business model, investor owned or electric cooperative or public power, that creates strength and creates more resiliency and protection from cyber attacks and other malicious attacks. But then our similarities and how we're increasingly architected and relying on technology presents some real vulnerabilities. And I know we have a supply chain panel coming up, and they might touch on that. Out of the 16 critical infrastructure sectors designated by the nice people in the federal government about 15–16 years ago in the energy sector, which is broken into three sub sectors. In the electricity sub sector, we're pretty proud of ourselves for having been under mandatory and enforceable million-dollar-a-day fine enforceable cybersecurity regulations for almost two decades now. And that comes to us from the 2005 Energy Policy Act. This is bonus material for the students in the room. 2005 Energy Policy Act, the reliability title empowered the Federal Energy Regulatory Commission to establish and strengthen some capabilities at the North American Electric Reliability Corporation or NERC.

So Jeff's colleagues and my colleagues and folks at utilities all around the country are busy every day. Implementing book after book after chapter of physical and cybersecurity standards that have done a great deal to protect us against the geopolitical environment that we find ourselves in, which is obviously the source of a lot of these cyber attacks. Cybersecurity regulation continues to mount up for our industry. I think in March, Congress passed and President Biden signed some additional mandatory cybersecurity incident reporting responsibilities for us. So we have a really good baseline of protection in regulations that are crafted in a collaborative fashion between people with deep expertise at the subject utilities, and regulators. So that works pretty well. But Russia and China and other mischievous places are continuing to pose problems and the threats are mounting. So we keep working. And we do a lot that we're not told to do, but that we, as industry experts coming together, have thought through and plan to do. I served for three years, and also some in some prior lives as part of the electricity sub sector Coordinating Council. And this is a body of 32 CEOs from across the electricity sector–sub sector, who come together on really bad days, and I don't think our country has had a black sky day yet, I hope I don't live to see one. I'm afraid that I will though. So on grey sky days, really bad hurricanes have been primarily the events we've seen. Or some cybersecurity events or threats that nobody really heard about. Those CEOs come together and a bridge, a virtual bridge forms over to the federal government. And very seamlessly. It gets better every year, a lot of information passes back and forth between the industry and the federal government. And the situation is managed better. There's better clarity from the public side to the private side about what we need to do and what resources we might deploy.

So hold that out as something for maybe a future conference topic, how does that sector coordinating council work? How can other parts of the energy sector over a nuclear or over in fossil fuels how can they adopt that model, and improve upon it to in order to make energy security overall, rise up? We get a lot of interest from our federal government partners, some at the Department of Energy, some at the Department of Homeland Security, some at the Department of Defense, and sometimes in other alphabet soup agencies, the NSA, FBI, they want to come to us and work with us in the electricity sector on how to get into our systems and use our data and our vast view of the entire geography of the country. They want to partner with us to get a better view of what's going on. Not only in our infrastructure, but extrapolate that to better understand how our adversaries might be looking at all of our critical infrastructure. They certainly have this type of cooperation in finance and telecom. But I think that electricity has been a real leader in this type of partnership with the federal government.

We also have business models inside our own sector that leverage well, that binds us together. We have a program called the cyber mutual assistance program that the government didn't tell us to do it. Thought Leaders EEI the Southern Company, public power. And electric cooperatives came together and said this is an issue where we're better together. And we can all think we have to band together in order to out think the adversaries who want to get into our systems. So this program draws on–well, it's phone a friend. If I'm having a problem on my Telecom, infrastructure or my IT infrastructure, or worse yet, the computer infrastructure that runs the generating plants, if I'm having a problem, and I've got malware and ransomware, and other evildoers in there, and it's outpaced the capabilities of my IT team and my experts, then I'm able to phone a friend and call down to Juno Beach to Florida Power and Light, or up to Atlanta, or anywhere in the country where I've established relationships. And I think there's a common understanding of how our networks work, and bring in resources and

help work through the problem. And almost, I think now we have 85% of the electric utilities in the country involved in that type of program. And we're making great strides in getting natural gas operators into it as well. So there's a lot of hope. And there's a lot of innovation and agility in this one critically important part of running the grid and keeping the grid and are keeping the grid secure and sustaining economic freedom.

What's missing, and I'll let David ask me more of what's missing. In a 20 year relationship with our federal partners and regulators, we're still missing a really consistent understanding on their side of the kinds of information and intelligence that we need in order to protect the grid. Someone mentioned this morning that you know, every four years, it's kitchen basket turnover, that's a real problem. We need to fund our federal agencies and our state Commission's we need to fund them with the personnel dollars and the incentive packages to bring in the type of energy experts and keep them there that are needed in order to sustain that bridge of communication. You've got to keep that going on the blue sky days. And it takes 1000s of people on the industry side. And on the government side. We also need—and I hope this conference can help to think through in the future conferences can help to think through—we need really clear sources of energy information in plain-spoken language were people who care about the industry and care about grid security and national security and all the good things that flow from those concepts where people who care about that can go and find the information, understand it easily use it and come back and talk about it and ask for more. So I hope—and I've hoped for a long time—that UGA can be part of the solution for that critically important mission. So thank you.

Dr. David Gattie: So I go cross country throughout the year giving talks. Usually I have to explain my accent from day one, but never have been preceded by somebody that used the word "y'all" in their presentation. So this was a first, Laura, that and Jeff, bless him, wherever the boy got his degrees from, we're glad you're here in sound like the rest of us. This is about transitions. And I'm going to focus on that part. We're going to look at it through the lens of security. But I'm going to tee this up with a couple of points—a couple of underlying contentions. Several things that I'm going to mention we've already talked about. So if we're going to beat dead horses, we're going to beat dead horses. First Energy. Pre-eminently, if you go back and I think earlier, maybe in the previous session, I can't remember who all mentioned it. It is pre eminently a security resource. And by that, none of what generally we were talking about on the security side, whether it's energy security, national security, climate security, economic security, none of that is that is valuated in your energy bill. It's a market commodity. Jeff has talked about it, rightfully so Jeff has explained that they have a responsibility to ratepayers for electricity to be affordable, as cheap as possible. But that bill does not include. If it's coal, it doesn't include that it's baseload and storable. If it's gas, it doesn't say it's dispatchable, there's no reward for that it's not monetized. That's a big deal. That's a problem, in my opinion, that we have in our energy conversation and how we set our policy. And I think earlier this morning, it was talked about that, at the margins, "it's whichever is cheapest, that's one we're going to go get."

I thought, Rich, you made one of the greatest points I've heard recently about how you don't get dinged when you're not available. You would think that if you're not there, there would be some consequences. But there aren't only when you're there. Second part, energy, we're pretty much talking about as a market commodity. But it's not, it's more than that. It's more than just a climate change discussion point. So my bottom line with that bullet is that it is central

to the strength and diversity of our industrial base. Mike Hewitt's talked about our industrial base, we've had conversations about the industrial base. The industrial base is what stands up this country, both economically and our defense, it is what keeps us the great power that we are. We talk about the industrial base and I think Laura just mentioned the critical infrastructure sectors, great power competition is no longer just a military issue. It's not what it is. It's now energy, resources and technologies. And we're living it. Tomas has talked about it this morning. We are living that, that it is now an instrument of national power. I could ask the question. I don't know what the answer is, is that how the US views it? I don't think so. But it is how much of the world views energy and the technology. So we're not going to have one without the other with the resource comes to the technology and all the industrial base that appends to that. This is the game that we're up against. So I want to focus on the transition state, we've talked about transitioning, but it's almost as if it's a step function, where you want to be where we are, and then be something else. That transition state if you're an engineer, or if you're anybody that works in anything, any ecological systems, when you're transitioning from one state to the next, that transition state is a vulnerable position to be in. Because it is a time where the properties are mixed. The system is trying to become something that it was, that it's not—something new. We need to pay attention to the fact that this is a transition state that we're discussing. If we look at the history, this goes back, to what? To '49? It's before everybody in this room, except maybe Gary Bertsch, maybe Gary was here in '49? Gary, you here 1949? Yeah you were, I wasn't.

When we look at—this is total energy consumption. There are a couple of things I want to point out here. Up until about that point, and going back, anytime the US discovered or unlocked a new energy resource, it was cumulative. We didn't displace something, we added it. It was diversity. And every time we added a resource, we added technologies, we became more diverse in the resources more diverse in the technologies, flexible, adaptable, resilient. Now that line they are showing diversity up until about that point. The question is, and I'll talk about diversity a good bit. You see coal going down. We still have coal. My argument here is we are still losing diversity because we're losing the operational characteristics of the—diversity is not just the presence of the resource. It's the operational characteristics of the technology that deploys that resource for use in our economy—that's totally energy. We're looking at the power sector, which is what we're focused on in this panel. It's similar. And I think earlier, we had talked about, I'm going to go back to the previous slide where our total energy sector, we're about what is that 79% fossil fuels. This is in 2021, our electricity profile right now we're about 60%. Fossil fuels, if we looked at the total world curves like this, it's up in the '80s. If we're talking about decarbonizing, that is beyond a heavy lift to decarbonize that, but this is our electricity profile, and you can see the trend here the coal trend in the previous slides, coal trend for the power sector, again, we accumulated resources became more diverse, fracking technology stepped in, and coal has started to go down.

Hypothetical question: if it had not been for fracking, and our conversation was about decarbonizing our economy, what in the world would we be doing? If it weren't for natural gas? I have no idea. But with that curve there, I would argue that the coal curve would not be going down. We'd be fighting tooth and nail to keep those coal plants open. So the question is, as we look at this transition, we are transitioning now from coal to gas that's just in one sector. We've seen issues come from it. I've been in several states where the transition from coal to gas has a state at about 75% dependency on natural gas, and they're worried it's flow resource, trying

to match up with a 24/7 on demand, kilowatt hour. It's concerned, it's a reliability concern. It's a security concern. So this transition state, let me just give a few properties of our current state. That system that we got out there, I understand that our grid is old. I get it. I understand that our energy infrastructure may be old. I get all those things. But that energy infrastructure that we have, has facilitated the world's largest economy, most advanced industrial complex, greatest military power, and essentially the steward of global security. It's got its problems we're working on 'em. But it's a dang-good system. So far. It emerged from the bottom up, it wasn't top-down totally, it was trial and error, mistakes, fix repair, just like an ecological system. It was organic, was emergent. It was bottom up. On occasion, national security would step in, we've had those problems back in the '40s and '50s, maybe, but we remember them in the '70s. And those that were around if you probably nobody was around, but the Power Plant Production Fuel-Use Act back in '78, literally stepped in for national security reasons and said "you can't burn any more natural gas for power plants, you got to build coal plants." That was a top-down decision for national security reasons, because it was clear that power grid was a national security asset. So that was top-down every now and then there's top-down intervention for always for national security reasons.

So we've got a diverse resource base, and technologies. Later the liberal international order—highly advanced. And it holds up all of our energy, national and economic security. The question is: the future state? I just moved everything over to the right, but just put lower carbon in there, it's all put in there. I don't think we want to lose those properties. Maybe. I ain't one of them, but move properties over. So we have some vulnerabilities if we're going to move from the current state to the future state. There are going to be vulnerabilities and risks there. So let's go through and just look at a few of the resource issues. This is going back to '65. Our oil, gas, and coal production. It's just production to consumption ratios. The dotted line there for one means we're producing as much as we're consuming. This is all three fossil fuels. We've always been self-sufficient and I won't use the word energy independent. For reasons being that we really aren't. We're always going to be trading stuff. We're self-sufficient on coal.

But look at the gas and oil curves. We were down at about a 35% self sufficiency on oil as recently as 2005. That means we were importing about 65% of our oil, gas, you see the curve there? I've got a couple of breakpoints there. When the curve's going down, we're vulnerable. People have us by the short hairs and they know it. When the curve's going up, my contention is we are subject to overconfidence. And our planning and policy strategy needs to be a lot more long-term. And is we can't just again, revert back to look at all the commodity we have. This is still a strategic asset. To the point that has been made earlier about nuclear plants, I beat this one up till the cows come home. The US used to own the industry. Mike pointed out earlier this morning back in the 70s. We were building the nuclear plant every 15 minutes, not really. But that's just an exaggeration. We owned it. All fuel all the enrichment technology, it was ours. You see what's happened, turn of the century, Justin pointed it out 155 reactors since 2000—Chinese and Russian, we've got two reactors, construction starts at Vogel back in 2013. When we broke ground, somewhere in there somewhere back in there, that's it for construction starts. As far as grid connections again, we owned all this. The only grid connected we have is Watts Bar. Oddly, the construction started on it in '73. We plugged it in 2016 was a heck of a construction time, kudos to the federal government. They just kind of put their shovels down for just a little while. It was just some issue. We're not there. We're just not there. Oil, gas and coal. We saw the curve, nuclear we saw the curves. As John mentioned earlier in

his talks, locked in, on orienting things towards carbon emissions, If we look at the record, this is since 2000. And these are not complaints, this is just the simple realities of countries using resources that work. Since 2000, we've got a total of about 8,000 million metric tons of CO2, you can see where the US and Europe are—old economies they can afford and we can afford to do that, because we got a baseline of fossil fuels, nuclear and hydro to tag on lower carbon resources. But it takes that baseload to do it. China, Asia Pacific regions, where I'll show you here in the next slide. That's where the economic growth is occurring. That's where population is growing. Again, if you look at this, and it's a triage issue, where do you focus your attention? If it's climate, if it's carbon reduction, you don't look at the patients that are doing well, you look over in the areas where they aren't doing well.

This is a little small graph, but to me, it matters because the US power sector is the one that's in the crosshairs right now, that top dark land is global CO2 emissions and all I've shown here on the bottom lines, our CO2 emissions associated with the total electric power sector, coal from the power sector and natural gas, if you subtracted them out, and it's just decarbonize the grid, you'd get those dotted lines at the top. The point there being is not that the US does not need to work on decarbonizing the grid, that's not my point. My point is what's the impact? This is the world's best power grid, I'd argue. If you decarbonize it, what is the return on that investment? Well, that's it as far as carbon reduction. Look at fossil fuel consumption around the world. And this matters in the context of what we're talking about security wise. Again, not a complaint, you can see the US and Europe, fossil fuels going down—in the rest of the world, China, in the Asia Pacific regions and India, they are increasing and it's just simple—it works. It's accessible, it's affordable, and it works today. And that curve is not going to change anytime soon. Everybody now knows that and admits it. IEA admits it IPCC. In fact, one of the things that IPCC will say, Rich, is if we don't come up with carbon capture and storage, all bets are off. It's just not going to happen without carbon capture. So here's some concerns. China and Russia are strategically exploiting fossil fuel resources and technologies and we're moving away from them. In the developing economies and moving in the same direction as China and Russia. These are the most valuable resources and technologies on earth and we are moving or proposing to move in a different direction, then the emerging economies, and the suppliers of resources and technologies, Russia and China and other authoritarians, it's going to reduce our energy resource and technology industrial base is going to do it. If that's the direction we take, theirs is going to increase, they will become more diverse. Industrial base will become deeper, broader, more flexible, more resilient, more adaptable, and ours will become thinner, less diverse.

So the question is what will be the impact on our national security? If our industrial base shifts asymmetrically, compared with Russia's and China's in the military, that's a big deal when you do not want your military to be asymmetrically less than the bad guys. In fact, we want to be dominant. America's competitors, they are and I think somebody mentioned that this morning, they are all the above, I don't use the phrase myself, because it's become a cliche, but it's all the above for them. And they are leveraging their state owned enterprises to meet their geopolitical objectives. Now, if we disengage two things, if we disengage from fossil fuels, and we don't aggressively promote nuclear power, who is going to be the preferred energy partner, for those emerging economies that just mentioned, who's going to be the preferred provider, it's not going to be us if we're not in the game. So a couple of points here are true transition. And this is what I'm proposing that transition period be, rather than indexed to a climate

pledge carbon reduction by certain date random or politically motivated, doesn't matter. It's terribly oriented. For decarbonizing your energy sector, I'm proposing that transition period be open-ended, flexible, and resilient to inevitable perturbations, and disturbances in our domestic and international supply chain is going to happen. So in that transition period, we need to maintain all the properties that we have now have resiliency, adaptability, and the capacity to respond. While we get to whatever that future state is, and also proposing that we need to be empathetic to and capable of engaging with those emerging economies in every resource that they need. That's going to be all fossil fuels, nuclear and renewables and batteries, natural gas, combined cycle, carbon capture and storage and advanced nuclear. With just simply last bullet need to be adaptable to shifting geopolitical conditions, they are going to occur a couple of policy proposals to establish a fossil fuel baseline that we do not allow our economy to drop below, so I'm saying that zero fossil fuels a bad idea, we establish your baseline don't allow it to drop during this transition period. Secondly, aggressive nuclear, you know, see Mike Hewitt—just aggressively pursue nuclear policies. So that transition state, three little descriptors, security centric, globally engaged in climate inclusive, not just carbon reduction. I'm done. So I will open it up to questions there, Chase.

Duncan: Thank you so much for that. Dr. Gattie, I think you did a really good job of teeing up this kind of broad view of the energy transition that we're seeing. So at the utility level, you know, with utilities all across the country looking to make major changes towards lowering emissions. This requires developing new generation assets and new investments in technology and infrastructure. So what would you say are the biggest challenges that utilities expect to face in this energy transition?

Schepis: Okay, well there's more than one, cost sensitivity, I described our population. I'm going to say 15 years ago, I ran a market research study across the Electric Co Ops. If we raise your bill $5 a month in the name of green power, are you okay with that? Yeah, pretty much 65%. We're okay. I said, all right. If we raise it $10 a month. How do you feel about that remarkable decline in the yes, no, I have not run that same market research study in Northeast Florida, but I'm about to, and I suspect, the answer will be about the same. It's not because people don't care. It's because people are truly strapped for cash. And, you know, you can go to Costco or go to the gas pump. And you can see that and empathize with it. Another big problem right now is the supply chain for building new infrastructure. And that's fuel and technology, agnostic. I've got big developers who are coming in, they want to build an apartment building or the next shopping center and getting the pieces and parts to make that possible. Lead times and prices are up, translate that into also delivering them energy. If you would like to develop a solar farm right now, it is not a "decide to build it, and it will be there" type of proposition. Lead times are stretching into the years.

Grubb: Yeah, I think I would add a good part is one of the—there's two things, I'll have two as well. You know, reliability always has to be up front. In terms of several aspects. So when I think about it, I'm on the generation side. So I'm thinking from the standpoint of how is the fleet flexibility going to handle these more intermittent resources? How do you do that? We've teed up several things in RP on what we need there, then there's the transmission side and the transmission side has been built on, I can avoid some transmission projects, if I can generate from this source that source helps me. But that source has been dispatchable. Central Station is there. An intermittent resource looks different on the transmission side as well. So how do

you take the time, it's really time, to make sure that as you as you move forward with adding renewables and adding storage, we've always used the phrase and Commissioner Echols has heard us say this a million times measured and disciplined, right, make sure that you're going through it in the right way that you're not going too fast. But you do need to move that way. The other thing that we're seeing is that balance that we have to handle, especially in Georgia, lots of all of our new load and all our new customers and economic projects are "I want to be 100% renewable, I want to be carbon free, I want to be 24/7 carbon free." But the whole customer base can't afford that. And we'll eventually get there, but their goals are a lot more aggressive. How do you handle that balance of I've got a colleague who likes to say "I need to think about Jim in Hahira and Sally and Savannah," right? I gotta know what it does to them as well, not just the big tech company that wants to come in. So how do you handle that balance? And we've done a really good job of working with a commission on programs where those customers can subscribe to our renewable megawatt hours and those types of things. But that balance of customers who have really aggressive goals, all about sustainability goals, but we don't plan for specific customers, we plan for the whole base. That's a challenge that we're trying to think through as well.

Duncan: Alright, thank you. This next question is, I think, for everyone, but in the past, integrated resource plans were primarily to ensure adequate supply of resources, plenty of generation capacity, and low rates, but with climate considerations shifting towards renewables, and with China having such a tight grip on global supply chains for renewables, as well as the whole cyber issue that we brought up earlier. How much of an impact does America's ongoing competition with great powers like Russia and China come into play with a US utility? And if it doesn't play much of one to what extent should it perhaps?

Gattie: I'll start because I don't know the answer to this and I would love to know. And we talked about this, Chase, actually just now at lunch. Commissioner Echols was in there. I don't think that it plays at all in their boardroom decisions. I don't think it can. I don't know that it should. So the security aspects of that again, since they aren't monetized there's no prospect associated or assigned to them. I think it just becomes a good feeling on the part of the utilities which would be a mistake if y'all are going to try and dress something up as a national security issue. I think on the supply chain part, I think they can answer but I think they know what they're up against on the renewable side. On the nuclear side, we're just as at risk, because we really don't know without a nuclear industrial base review whether or not we have, right now, the supply chain as a stand up a small modular reactor program, which I don't think we do. But I think the supply chain issue, hopefully they'll talk about the next session, are going to bolt to the top as probably the most latent risk out there, and we just don't see it.

Grubb: You know, I think you hit on it. Tom Fanning the southern CEO's involved in a lot of the cybersecurity aspects. And we look and think about resiliency. Think about reliability, we think about, you know, you know, having a diverse fleet, but you're right. Now, today, we don't have a number that we put on it. Right. And so if you've got something that looks very uneconomic, it's hard to argue to do it for another reason. And so we do use it in terms of balancing outlay, you know, if something's a kind of a middle of the road on the economics, you can do that. But you're right, we don't. In my everyday, I'm not thinking about Russia and China other than I am starting to think through now. Supply chain stuff, renewables are seeing some delays there. That's not good from the standpoint of there's benefit to having those get online

and get off some energy value. But the lights won't go off if they're not there. So there's not that it's still not important. But it's a little different than, hey, I've got to have something dispatchable added by 2025. Or I'm having enough resources, and it's not there. So we'll have to, I have to go through that. A lot of our stuff, we're looking at the late 20s to actually deploy, so we'll have to see how that resolves itself. But so you're right, we don't have that number that we put on. And we all love that as engineers, right? If you can just give us numbers to get there, we'll solve it all day long. We've struggled that way with fuel diversity, I think the industry has never been able to put any kind of value on what diversity is. But we are starting to capture at least like flexibility value, we're running some models that looks at "if I can be more flexible, there's a value to it." So we're trying to capture that from a reliability standpoint. But yeah, a lot of moving pieces. I think more. Especially lately, and especially I've been here today, on a storage standpoint, and that rare earth aspects of storage, we've got a pretty robust storage plan laid out ahead of us, but we are looking at some other technologies, like the iron, air batteries and things that have a different material to them. I think that's something we're all going to have to say, because you just sit back and think fuel diversity is gas, coal, whatever. Southern has always been diverse from coal suppliers and has been diverse on gas supplier. So there's that generation diversity, but there's diversity within there, I think you're going to have to have that same kind of look on the material side as well.

Schepis: We have actively educated our board, and are very assertive local media about how the things that they're definitely already aware of in geopolitics are directly impacting their local utility, our natural gas prices, our hedging strategy, and the fuel charge that is a line item on the local bill. We, I think, are going to dial that up. We continue to talk with them about the good decision that we made many years ago to enter into a contract for nuclear power. We keep educating on that. And the national security line of reasoning is something that I'm the hearts and minds lady at the utility. So it's pretty easy for me to dial up that education and that rhetoric on the cyber side. We have a lot of investments ahead. We have a lot of antiquated telecommunications systems. And as we digitize the grid, we have to make, I think it's going to be a billion and a half investment over the next 12 years to get to that agile, innovative digitized grid that is also incredibly cyber resilient. So yes, we have such a story to tell and so many investments to make. And it's incumbent on me and my leadership team to provide that full and transparent set of reasons. So national security is going to continue to be a big part of the story and get bigger

Duncan: I think now it's time for questions. So we'll take some questions from the audience now.

Audience: Thank you so much. Jeff and Laura, this is both of y'all's area. And going back to a comment you made, we've talked a lot about national and international. But at the end of the day, we're mostly Georgia, Florida, market takers on a lot of these policy things that we can affect with the margin. But specifically, with respect to electric cars, you know that it's going to happen at some point you can take for whatever reason out of it. But Google CNBC survey of auto executives think by 2030, their median number was 52% of cars are going to be sold electric. Now there's a huge supply chain of whether or not that's going to happen, but let's just say they're right, some of the highest estimate they had was 90%. Some car makers think they're getting well, Tesla already has 100%. But you get the point. If we get to that number, from a generation capacity in your plan, and from a grid, do we have the ability? I mean, are we factoring in the increased load that we're going to be transitioning fuel that currently comes from

a pump that's now gotta go through the electric system that we have and the grid we currently have? I mean, what does that look like if the top end of these projections happen?

Grubb: You must have been listening in to Commissioner Echols. And I this morning, he said—

Audience: I'm aware of him and his touring the state electric EVs.

Grubb: He and I were talking about that one of the breaks. But so we do have in our load forecasts and projections, I think is more of the middle of the road type of level. I'm not in that group. But so you know, we've got enough generation, depending on the plan now, the RFP for the next 5, 6, or 7 years. And so I think that something wants to stay in front of from the power delivery side, I can't really speak to it, I guess it's going to depend on really, when are you? When are you incentivizing people to charge them? You know, I think one of the examples we think back to is back when air conditioning boomed, right? We couldn't keep up with them. And I've heard folks at the company say we just fuses blew on transformers, we went out there and put a bigger fuse in. Alright. And that's how you kind of caught up with it. I don't know if it's that ramp. But if it is, maybe it's not during the peaks, right. So maybe it's a little different. I know, we're doing a lot of work on charging stations and thinking through that. But if it's on the upper side of it, I mean, I think as long as we stay four or five years out from a generation standpoint, we can do it. On top of that you've got a lot of big data center loads that come to the state. And so how are those impacted? So the projections, the good thing is we look at every year. So it's going to be interesting. I think you're right. I mean, I think EVs have a lot of potential. I think it's to the point this morning, just because they're cool. I mean, some of the best looking cars you see now are EVs and the performance. And it's just a great thing when I want one, I just had to buy my kids cars first. So it'll be a little while, but I think we can, as long as we stay engaged in that space, I think it'd be a good opportunity, maybe a great problem to have, right? There's so much load, you got to keep up with it. I think we'll be okay, trying to deal with that situation.

Schepis: We're in a very similar posture. It's in scope for our ongoing IRP, the consultants came in and told me last month that this was a little bit surprising. We have anticipated a 12% every-year increase in electric vehicles in Northeast Florida, which gets us past I'm no mathematician. But that gets us pretty far down the road pretty fast. And we're the same. I think we're not in fear that we'll be power short. But we have to keep a really close eye on it.

Gattie: Can I ask about pipeline capacity? Is that calculated into all that as well? Do we have the pipeline capacity to keep up?

Grubb: So pipeline capacity is a challenge. Building new pipelines is, as y'all've, seen lots of money, lots of time on projects that get canceled. That's why there's a lot of value in getting existing resources. That's one of the things we've teamed up with a commission on these PPAs we're getting is that they've got existing pipelines, you're able to use those. We are worried about that, in terms of timing, used to be three to four years now. What is the timing? You might can build the generation if you are going to build new gas, you almost have to build the pipeline as much as you're doing the generation it's a lot longer. So I think that's part of the national energy policy we've got to talk about, I think that's one of the things that tees up is if you've got a world where we're not building any new pipeline, you're going to need more than just existing gas, most likely, where is it? So it's a challenge. I mean, we struggle with it,

I think we're building Alabama's building some new brownfield gas. And that's even harder. It's not just the Greenfield, it's even the Brownfield stuffs a little—expanding existing pipes is a challenge. So I don't deal with it every day. Again, we're getting existing gas resources, what that future would look like, I know that when we look at some, could you build gas and early 30s, it's, our estimates are very expensive, on pipeline, and then the timing, you just don't know. And that's not the best condition to be in either, as you're trying to transition out of coal either.

Schepis: So sometimes, it's really great to live in Florida. And sometimes you recognize that you're on a peninsula. And you're one of the most gas dependent states in the whole entire country. And you're trying to go from 25 million people to 30 million people as a shared state goal across many stakeholders. So you do worry about the nice people in the interstate natural gas pipeline business. And you get together with your friends, and you start thinking how can you? You don't talk about having an RTO? We do not talk about that. But we do talk about expanding some power poles. And we're talking together about a Southeastern energy exchange market. Yeah. Same so that we, and you talk together about your transmission, so that we can make sure together that we have what we need.

Dr. Richard Axelbaum: I'm thinking of 30% solar. In the south, I know we think well, the sun shines in the south. But really the solar installation in South isn't like it is in the southwest. It may be half or something. So it's nice, but it's not great. And largely because of cloud cover and things like that. And you know, you just think you "well okay, if the capacity factor is a 20% 23%." So you're talking about 30% solar year round, that means that there are going to be times when you're effectively 100% of your power. And the heat of the day is going to be solar. There has to be that way. So then what happens at that point? That's one question what happens because you literally are saying that, I'm going to be able to get 30% of my power once well after have sometimes 100%. And that means everything is shut down, waiting for the sun to go down. Just try and say how you manage that. And the other question is, what is the scale of land use? For that amount of solar? It seems like we're going to see the entire South cover with solar panels. So any comment on that?

Grubb: Yeah, so I'll take the first one first. So from the solar—you're right, so like in a shoulder month, we get a lot of good solar penetration. You don't have your peak load in April or October. But we're able to model that, we look at that. So from a planning standpoint, to be able to serve that load, we use very little capacity equivalents on that solar. So that pie chart was megawatts on the ground, if you were to put on what we plan on from a reliability standpoint, that solar would be a lot smaller. Now we call it an ice factor. It's basically capacity equivalents. And so we still plan the system to have enough other resources to get very close to that reserve margin. So we have a 26% reserve margin that we've requested in the winter. Solar counts very little, if any, towards that. 26%. So from a planning standpoint, we're covered that way. Operationally, that is one of the things that will be a challenge for us. We've got around 3,000 megawatts online now. As you get to that five or that 7,800 or 8,000, we've predicted that's one of the things we've teed up is we need storage, because it's able to respond to that intermittency, but it also allows you to not have to curtail it as much. SEEM that last spoke is in our hourly market, having a 15 minute period that if there's unused transmission, we can all share renewables. You don't have to curtail them and then having that operational control. Where when you have your first solar units coming on and resources come on, you can just run them. You don't worry about it as you get more and more, you're actually going to need to dial those back to

exactly your point. We've got other units running. So we're working through that. We've teed up a lot in this IRP to continue to learn that. And then I'm trying to remember your other last question. I thought so long, I forgot the other point. I'm sorry. Land use? Yeah, I'm not the best on acres per megawatt. I mean, we are building a lot of solar in the state. I think Commissioner Echols can replay this. I mean, I think a lot of our farmers and land that is leasing that out, they see that as a very good revenue stream. So South Georgia has welcomed it, but there are some that are like, I don't want it anymore. So there's that balance. We have a lot of large farms in the south, it will be interesting. What we've teed up is because of that point I made around load in North Georgia, what we're recommending to the commission is our next solar solicitation to be in the north part of the state. It will be interesting to see how that develops. You know what there is land in North Georgia, it's just not quite as good. So we're going to look at prices, how robust that is. So it's a lot. But I mean, I think it's just what we see right now is a three cent per kilowatt hour energy resource. How do we best take advantage of it? We can't keep doing it forever. But we see at least getting out to the early 30s continue to be able to add some.

Harju: So one thing that we've seen in the West Coast is a move to ban new hookups for natural gas for residential use for certain commercial uses, and so on. Of course, my own commentary seems kind of silly when you are going to convert things to electricity that's half dominated by gas generation considering that you use it for heat at what? 98% efficiency. And if you flip it over to electric, you've just lost half of that efficiency. Are you seeing similar silly things in this part of the world?

Schepis: That conversation has not reached Northeast Florida. We just historically don't have a lot of natural gas distribution to the home, we have. You know, we have a little bit of commercial industrial use of natural gas so it's not going to really become a discussion. The infrastructure is just not there in our part of Florida. But you're probably aware, way down south, I think Miami Beach has made that type of move. So JTA doesn't really have a position on this. I'll give you my own personal position. You know, utilities are in the improving lives business. And I generally think it's not our place to designate what people can and can't have in their home.

Grubb: And I'm getting a little outside my knowledge being here, but I'm going to try it. I've been so involved in IRP that I haven't followed a lot of the state legislation like I may could've but I'm thinking there was some legislative action in Georgia, or at least some discussions around possibly restricting that type of ordinance to say "no, we're going to let municipalities be able to continue to offer both" I'm not 100% sure on that so it's subject to check. But I remember there was some discussion. I can't remember it was just a proposed bill, but it was something along the lines of that they didn't want to do that type of a restriction to be able to allow options subject to change. But that's about all I've seen on it though.

Braden Sanders: Hi, thank you for coming this afternoon as well. So Mr. Grubb, you mentioned during your part on building out the grid in Georgia and adding on new resources and emerging technologies, exploring the tall wind technology, right. And you mentioned some of the logistical problems as far as transporting the towers. What are the methods being looked at to kind of get those where they need to be? Is it like more train air putting it together and like stacks on site Lincoln Log style?.

Grubb: Yes so the pilot that we propose is actually fabricated on site. It's a spiral-weld technology. They've done it in Texas where they basically would bring it to wherever you're going to put the towers. And it's actually just a spiraled well, to get the diameter that you need. And then there's a very, I've looked at the slides, I want to go back and study it—my engineering mind. I wanted to engage a lot more on how you actually do the cranes to actually continue to build that. So you're really looking at both spiral-weld, and then how you're going to, it's really awesome, just like the crane kinda climbs the towers that build—the cranes have always blown my mind. I'm a civil guy, so I need to figure it out. But so it's really just fabricated on site. And that's really what we're trying to prove. The turbines, they've been deployed, so it's not the turbines, it's the ability to manufacture it on site, to get that tower height of 160 meters. So that would put, I mean, I think with the tower in the blade that's as tall as anything downtown, except maybe the nation's bank building. But we really do think there's some resources up there and in those high heights, and if you're going to do several thousand megawatts of renewables, wind really could complement solar very well, so that you don't have to have quite as much storage for shifting and those types of things. So it's really that spiral-weld, technology. So there's a great video on it, I need to go look and look at it again. But the other good thing about it is I think the iron that they're using is from Alabama. So as we're talking about security, the materials for that is out of Alabama which has a benefit. So we don't put a number on it, Dr. Gattie, But that is something we're like, hey, that's good. From a security standpoint.

Gattie: About your materials coming from Alabama? It's a little questionable.

Grubb: Not the school, just the state (laughter).

Jason Perry: I'm Jason Perry. I'm the Campus energy engineer here at UGA. My office buys about $16 million worth of electricity from you, every year. Thank you. Works great. We love it. Glad you love it. Since nobody was asking a question I figured I'd throw out what can we do here both with campus as a living laboratory as a concept that we are have been talking about for years at UGA to engage students in all of these topics using our infrastructure, but also just as a customer, you know, over since 2007, we've reduced our energy use intensity overall, by 23%, up until COVID, and then COVID, as everyone's aware, that throws the data off quite a bit. So that's a broad question. But what are some things that we can do as a sort of a niche customer, we have our own 100 megawatt substation, that's our interface to Georgia Power. Not a lot of people have that. But it is a big place. I mean, the population here is five times that of the town I grew up in. So it's a rather large facility that has a lot of potential.

Grubb: Gosh, that's a great question. And my first half of my career was involved with working with customers, and I've been out of so long. I'm trying to get my head back to that. But from a student standpoint, I mean, I think we've all talked about the importance of all these issues. We've been discussing security, everything. I mean, how do you get students to understand that it's not just about climate, when that's what you hear on everything? And really how exciting it is? I mean, this industry, I've been here working it since I was 18. So it's been 30 years. It's vastly different, just in my 30 years. I mean, what excited me about it when I started is completely different than what excites me now. And it's the fact that it's so crucial. You know, I think, how do we get students to understand how important energy is in terms of the facility and the campus? I mean, we've got a lot of programs, I think this would be a good point. Those types of customers like UGA to have that size as we continue to look at distributed and micro grids. And do you move away from Central Station? That seems like the place it

would more likely work? You know, we talked about the military, which is one or you know, municipalities, universities, schools, those are areas where you can do projects that you can't do with the majority of your 2.7 million customers. So how do we partner with that? I don't have any answers, but I think it's a great idea. I know we've done some solar here with you all, as we look at how do you decentralize a little bit? Those would seem that to me, those would be the kind of customers that we could work with on how we do that. We had a little bit of discussion at lunch around SMRs and the apply to commercial military base as opposed to for everybody and grow it. Not saying Georgia's gotta get one and it'd be awesome. An SMR. But it'd be cool. It'd be a lot.

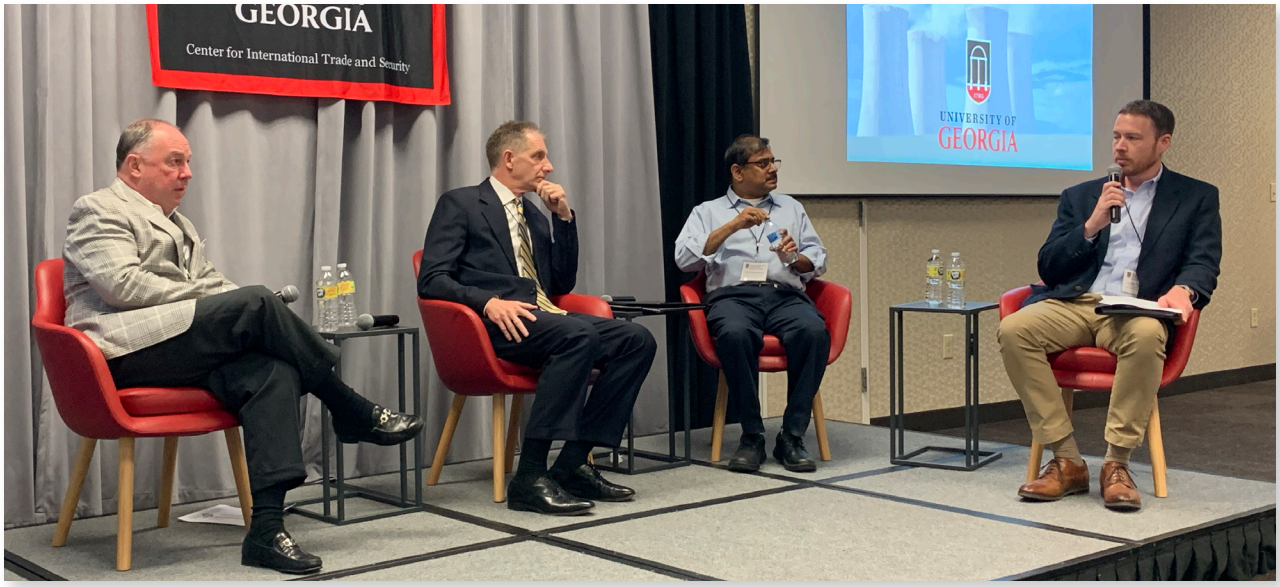
Gattie: So Jason I'll talk just a little bit on that's on the demand side that's on the consumer side. From having taught this for just a little while one thing that I think they'd be, well educated owners if they could get upstream to the technology and just understand, even John was just talking about efficiency, burning gas versus running through a power plant. Students don't necessarily know that solar is not fungible with natural gas or with coal or that capacity factors in efficiencies, I think they'd really be, it'd be a great experience if they could learn. We've only got a few resources, three categories, fossils, renewables and nuclear, to understand those technologies and the limitations on them, instead of thinking any of the ones are the magic bullet. So I think on the demand side, and on the production side, the generation side, I think they'd be well served with both ends of that.

Schepis: What I hear you saying is that you're doing some really great things. And you want to tell that story. And you want to get more the students and the surrounding community educated about what you're doing. And so I think you should feel encouraged by today and by this great network to pick up the phone and call the College of Engineering and call the College of Communications and get that story told, I think about our own commercial and industrial customers down in Duvall. Some pretty sophisticated companies. We've got a couple of universities in the area. Everybody is just hungry for information about how to do things differently and better. And you think, wow, we're also awash in information sources. But it's still really hard to find good examples told and told in a clear way. So if you think you're doing something fantastic, ask for help and tell the story because there is definitely somebody out there who can benefit from it

Duncan: Alright, I think with that we're going to take our break until 3:30. So if everyone could join me in giving our experts a round of applause. Thank you.

PANEL FOUR

Supply Chains



Left to Right Rob Sweeney, Will Cook, Dr. Gopi Munisamy, Dr. Justin Conrad

Dr. Justin Conrad: All right, welcome back. I want to thank those of you who have been here for the long haul all day, we're going to end on a very interesting note. I think we've had a lot of good discussions throughout the day, a lot of good creative ideas, from a demand perspective, how we increase efficiency to the distribution of our energy portfolios. But the truth of the matter is, if nobody outside of this room is ever to hear of any of these ideas, and nothing changes, the energy sector globally, is still poised to grow exponentially in the coming years. To ensure that the world benefits from that growth, rather than just incurring additional risks and vulnerabilities that's going to require a safe and secure supply chain. And so that's what our esteemed panel is here to talk with us about today. And here on my immediate left is Mr. Rob Sweeney. He is the head of Energy and Infrastructure at NX solutions. He has over 35 years of experience in the industry. He has been involved in a number of nuclear projects over the years, in many cases setting industry benchmarks. He's also currently serving on the Civil Nuclear Trade Advisory Committee, and he's a former member of the U.S. International Trade Administration Small Modular Reactor Public Private Program Initiative. To his left is Mr. Will Cook, who is the co-founder and CFO of QED analytics, a private defense contractor specializing in engineering acquisition, business operations, and research. Will directly supports clients by conducting industrial base and supply chain risk analysis for DOD programs. Recently, he supported DOD efforts to assess risks associated with the COVID-19 pandemic and the Russia Ukraine conflict. Finally, we have Dr. Gopi Munisamy, who is a distinguished professor of agricultural marketing here at UGA's College of Agricultural and Environmental Sciences. And he is a Faculty Fellow of CITS. Despite all of the lengthy CVs that we've had in this room, today, it might be safe to say that Dr. Munisamy's resume is the longest. However, somehow in our program, he ended up with the shortest bio, so I'm trying to figure out how that happened. But we have to cut out a little bit of it. But just to let you know that his research focuses on agricultural markets, trade, and policy and supply chains. And prior to joining UGA, he led the agricultural market and trade research programs at the US Department of Agriculture. So we have a great set of experts here. I will ask them a few questions after they are finished speaking. But we encourage you to ask them questions and take advantage of their expertise while we have them all here together in the room. So with that, Mr. Sweeney.

Rob Sweeney: Thank you, Justin. Thank you Dr. Gattie. And thank you University of Georgia for allowing me to be here. Can everybody hear me? And where are the students by the way? Is there a Wednesday afternoon darty that you guys are supposed to be at because half of them are gone. For those adults in the room who don't know what a darty is, you should go find out. I've been to one; my son brought me one. But in any event, thanks again. Okay, so this is just the model to keep it simple and maybe a little education for some folks, maybe not. But this is my kind of view of what drives supply chains. And so they also work together and supply chains can be a variety of different things. I'm going to focus on three areas. We talked about fossil fuels enough today in LNG, so I'm going to focus on a little bit of renewables and some observations that I have had and other people have had. And then the nuclear supply chain and some of the observations and some of the complexities that are built in with that, and some of the opportunities and challenges going forward. So that'll be pretty much it. And I'll try to do this in 10–15 minutes. So essentially, in order to start things off, you have to have a demand, clearly, and what we also see is we need that demand to be met by investors. We also need to know if the policy is consistent with policy. And, oftentimes, Washington will send or your state houses will tell you what the policy is. And then you have to go create things and fit

the demand or create the demand, or provide the investment without their help. So there are a lot of complexities with this. But to keep it simple, these are four things to keep in mind as we go through the other slides.

So with regard to supply chain, it has a responsibility—it's, for the most part, to deliver three deliverables, from my perspective. I'm more of a projects person, and always look at labor materials and equipment. And materials, as I was reminded earlier, includes the fuel. So when I'm talking fuel, you'll see that in there. So to me, in order to have an effective process, to deliver those deliverables, you need to have certain controls. And you need to have the capabilities to manage those controls. And one of the things that we see in the industry, and since our commissioner is not here, we can talk about one particular project—yours, and others that have failed, you know, to have the project management acumen and the overall wherewithal to pull this off together. It's not easy, it is definitely not easy. And so when you go 30 years without accomplishing projects, you can't ask one utility to carry the burden of 30 years of bad policy or lack of education or lack of trade experience and things like that, especially in nuclear because nuclear, it's a different trade group. And so from electrical and mechanical, to civil structural, to welding, it's specialties. And I'll get to that a little bit more. So briefly on just going through the wind and solar supply chain, keeping those things in mind, I said as demand, investment, innovation and policy support. As far as wind and supply chain, concerns are for solar and wind—both have a high level of demand. I mean, they basically have been foisted upon many states and regions to implement that to meet certain goals. Clean air or netzero, whatever. But at the end of the day, these pipelines have been pretty well full with a lot of incentive: investment incentives, production tax credits, investment tax credits. And we are seeing a little bit of slowdown on the wind side. The installation forecasts are kind of waning, and so the demand is starting to shift a little bit, I think there. Also on the innovation side, we see a lot of positive things there. Everybody sees those curves: the cost curves for solar and wind. And, also, the capacity factors for particularly wind and the efficiencies for solar have increased, making it a more tractable, attractive, and investable opportunity. But more importantly, we've seen without a doubt the most significant amount of federal and local policy support on this, and you can't have enough policy support. And, in this regard, policy supports can give you whatever you want, but they can also take it away. So with that there's a two way street. So, back to those three areas. I talked about labor materials and equipment. This is where the picture doesn't look so pretty anymore. Labor. It has a lot of labor. Half a million people allegedly in the market in the US at least. But we have less manufacturing capacity here in the United States, and the skill sets required are not necessarily high paying, not college educated etc. So it creates a little bit of a problem for the labor market, and on the mid material front and the equipment side. This is probably the most disturbing side, especially when it comes to our solar. There's just two figures here. 97% of the world's production of silicon wafers occurs in China. It's not here. It's a big problem. 75% of the silicone, and the cells that we put in the United States come from China. And these are DOE's numbers that recently came out, so I'm not making these things up. But at the end of the day, we have no capacity for wafer cells and silicon. It's not not good, especially in light of the geopolitical things that we heard about this morning. And I've been reading about it for months and years.

So I'm going to talk about the wind a little bit. And if you could see right here, this is about four and a half billion dollars of US imports for specific equipment to support wind. Wind, has probably a decent job outlook. It has been slowing down a little bit, I think. And the man-

ufacturing, unfortunately, isn't here. Most of it's overseas. So, once again, great on the front push by policy, and investors they all want in, but at the end of the day, it's not happening for jobs, and we're actually sending money to China and to other countries that may not be our friends tomorrow. So, with that, we also see shortages in rare earths, with the magnets in particular for offshore. Everybody's read, I'm sure, about the blades and all the challenges with that, and recycling or lack thereof, and disposition of that waste. So these are development challenges for them. And still no solutions in sight. So my favorite subject is nuclear. And by the way, full disclosure, I work with Mike on some very big projects overseas. And the picture of the United States is so different than what we see in Europe. So different. It's about heat in Europe. It's not about LCMV and cost of electricity. So I'm going to look at this maybe a little bit differently and maybe say some things, so excuse me; it's going to have a little bit of a European flair without the French. So with that, as far as the United States go, I mean, some of the youngsters in the room, I used to be one of them, were in the business very early. And I don't know how many people are actually going to go into the nuclear business. Is anybody planning on going into the nuclear business?

Well, hopefully we can change your mind. But in any case, as everybody knows, in this room, the demand for nuclear power has been pretty lackluster only until recently 2005–2007. Obviously, Southern and Georgia Power and some others took on a couple of projects, and hopefully we'll see that come to fruition soon. But from other areas, particularly overseas, major signals on nuclear, major signals and as I said, it's not necessarily about the electricity; it's about the future options for delivering heat and also electrolyzer used for hydrogen for buses, transportation and ammonia generation. As we heard this morning, there's a lack of ammonia in Europe. That means there's a lack of capacity for fertilizer. And this is what I think we'll hear more from later on. So with that, on the investment side, we've seen a lot of positive things in the last couple of years, particularly on the Gen three plus. You've probably read and heard a lot from us: Scale, X energy and the ARD program from DOD—a lot of funding coming from the government, but also a lot of interest coming from people from private sector funders and it's starting to pick up. And also we see on the investment side that we're seeing positive feedback from Europe right now on the taxonomy, and hopefully that'll stick so that new goal will be seen as a clean green investment. And also we're starting to see the ESG crowd come out of the closet and start to support nuclear. So it's an interesting time for them too, even though we have some challenges. Still, some are holding back their support on the innovation side. I'd obviously to get things going. We can't be building plants that we built in the 70s and 80s anymore. So there's been a tremendous amount of innovation that's been put forward from the advanced reactors that are doing things with fuel. They're doing things with passive and digital technologies and digital twins. We're seeing a lot of younger engineers come into the picture, because it's just not your grandfather's nuclear reactor anymore. There's a lot of optionality that's been brought to the table. So it's very encouraging. And so with that, we also see the advent of the micro reactor programs. PELE, it's a Defense Department project that's taking off this year, and we'll make a decision here soon on the technology provider. But we see a lot of optionality in the heat and the power side going forward. So, with that, we see on the policy side nothing but great news. I've been in this town of Washington, for God knows too long, but it's never been a better time in Washington for nuclear support. And it's bipartisan, and it's strong, and it's deep. So with that, we hope to see a little more legislation come out. Senator Manchin, Senator Rich, came out with something a couple of weeks ago. There's a couple other pieces of legislation that are promoting foreign direct investment, which

should be very positive that came up I think, this morning, as well. Some see it as maybe a negative, but maybe not. I see it as a very positive thing, if we can get maybe some investment into the United States, into some of these reactors. On the development side, that means to actually build one, we see foreign direct investment in the reactive vendors so far, and we've seen a stronger supply chain and some mutual cooperation and CO development going on. And there's been a number of recent announcements through NuScale and a variety of others like TerraPower, Bill Gates's company that has a small modular reactor. So a lot of positive foreign engagement with Allied like minded countries, and their major companies within those countries.

But in the nuclear supply chain, it is global, and it's very interdependent. And then relationships have a lot to do with trade relations that exist with the countries. And there's always going to be debates on who's trading with whom on certain things, but it has developed pretty well over the last 20 years. And part of that is because of the atrophy and the variety of countries. But they've seemed to come together and support a number of the various ongoing projects. And I just have two examples. This is the AP 1000, the Westinghouse reactor, which is the same reactor that's being built at Vogtle. And this is just a map to show you the variety of global participants in the supply chain from Japan, Korea, all the way to Europe. We have South America, Canada, all over. So this is a positive thing, in my opinion, because these companies are investing in the future of nuclear. And but for this opportunity here, like WAEC, and what the Koreans are doing, and a little bit of EDF, our industry would be in a big hole. So kudos to those companies. And so here's another example. And this is just kind of focusing on a project that's being built by the Koreans in Baraka in the UAE. And this is just a focus of the supply chain. Korean-designed plants are being build in the UAE and are relying on US companies and supply chains. There's over 175 plants. Probably a little bit more than that. This is a little bit dated, I think there's maybe 190, maybe 200 At this point, and it covers 33 states, and well over 1,000 people and at this point. This is a four unit power plant of 1,400 megawatts. So it's several times the size of Vogel and the content that was purchased by that project. The UAE utility, as well as the Korean team that put it together, was close to $3 billion. So there's a lot of US content in that plant. And we see a lot of U.S. content in other plants across the globe, because of the way that the market is set up. So just a depiction and it's pretty much all over the country. This I just put in there to just articulate what the Admiral had to say earlier this morning, and some other folks, about part of the materials that we have to deal with, are unfortunately being controlled by Russia right now. And so this is really just an observation of, and depiction of where, excuse me, where most of the uranium is. Obviously, Australia, the U.S. has much—not as much as Canada, of course—but we have a lot in the Russian region. And so just to give you an idea that we don't always control some of these materials. And in that regard, a lot of the materials, as I said earlier on, the solar and wind are not in our control, well above 80%. In some cases, the Chinese have total control, and we have none. And so, too, many of our allied partners across the globe don't have much of the underlying minerals and materials that make up those technologies. So I'll just move quickly here. There's, I guess, two more slides here. One, one is looking at the challenges going forward and at some, hopefully, opportunities going forward. So, you know, I hope that we don't see the impacts that we had with COVID. That was two years of somewhat hell with work locations and trying to do projects, especially in tight quarters, like at a nuclear power plant, very difficult. One of the challenges we have going forward is harmonization on the international front with regulations and in codes and standards, lots of effort being put into

that. It's like going to different states to get your driver's license. It's not so easy, some places, other places, there's reciprocity, and all that stuff. But internationally, every country pretty much has their own standard, in some countries that we're trying to build don't have any standards. But I will tell you in the Baraka case, they built those four plants without having any regulatory system, without any infrastructure, very few nuclear engineers, and they were able to do what they were able to do within 10–11 years. So we can do it—work together. There are harmonization efforts at the various agencies in Washington—Department of State, and the Nuclear Regulatory Commission in particular. So that is a big thing. And once we get that where, essentially a license can be fungible, it will really help us companies, because if we're there first, we'll be able to take the reactors pretty much anywhere, so it's very important. The other thing is challenges going ahead. I've worked on numerous nuclear projects and other projects; quality is always a problem. It shouldn't be a big problem, but you'll always have quality issues. But we need to work harder on those, because nuclear gets much more scrutiny than any other technology. So quality is paramount. And it's important. And there's been a history of this. You can't catch every bandit that's trying to cheat. But a lot of these sub components or whatnot are made in different countries, and the quality programs are on paper. They look good, but they don't police them. And they've had a number of issues in this as far as taking on suspect counterfeit parts and finding things in power plants that shouldn't be there that are not credible and don't have the supply chain paperwork. So, excuse me, the NRC recently came out with something on that and are taking a harder stand. So we'll see a little bit of ratcheting up on that. But it's always a good thing to be safe, instead of sorry. So another thing is that this is a challenge going forward, because of the diverse supply chain. We need to be careful about cybersecurity issues, in my opinion, particularly the embedded software issues, that you don't have full custody until you take that component on site. And so there's a lot of testing and a lot of procurement assurances that go in, but you never know. Also, we need to ensure that manufacturers and services firms are able to, you know, be properly capitalized and do their work on a timely basis and not put a large project under jeopardy, while also holding vendors accountable and contracts. We've seen a lot of that problem over the years, both here and overseas in particular. Also, one of the things with any construction project is assurance of project funding. And I know Mike and I are working on flexible financing projects overseas and it is a challenge especially for new kind numbers. And then one of the other challenges going forward is on the fuel cycle side, particularly with the fuel for the existing light water technologies. The HALEU is a problem right now, because we don't have the capacity to deliver what we see is the forecasted requirements. And so that's being worked on in Washington. And, hopefully, the legislation will accelerate that. There's been some numbers in the hundreds of billions, excuse me, hundreds of millions to a couple of billion to be thrown at that problem. So with all that, I want to throw out a couple of opportunities. The first one, excuse me, being the season: the opportunity to get what is estimated anywhere from 8 trillion to upwards a 30 trillion market opportunity for nuclear—that's globally. Also, to replace China and its material holds on and manufacturing on the dominance and renewables and displace that with hopefully more nuclear. And, hopefully, we'll see more opportunities this year, maybe this year. Senator Manchin is thinking that he might be able to get something done this year. We'll hope, but to get some legislation passed, there will definitely be legislation passed for nuclear next year, that will be overwhelming. So we have a couple of things we heard this morning about developing a closed fuel cycle that's continuing to work. There's been a lot of money spent on that. I have backup slides on that information later. But also,

we've talked about this morning, more bilateral, multilateral. And my conversations and webinars and talks I've given before, I've been pushing the notion that we have an end sixth convention of sorts, Summit, whatever you want to call it, with the top six nuclear civil nuclear countries on the globe, and along with a couple of other like minded countries. So those would be Canada, France, UK, US, Japan, and Korea, along with our other allied naval neighbors in the southeast and in East Asia. And so hopefully, we can pull that off in the next year or so, but there are some people working on that. So with that, I think I'm done. It's probably 12 minutes or something. But thank you very much. Look forward to questions.

Will Cook: Okay, thank you very much Justin, David, everybody, for inviting me here. This is a great conference, my first time to do something like this. And it's very interesting. Very, very exciting. So I'm Will Cook. I do defense industrial base risk analysis and kind of a common niche business; you don't probably don't run into a lot of people doing that. It's kind of a niche business until the trade wars kicked up. And then COVID came along. And now the Russia Ukraine thing and knowing where you get your stuff is kind of important to people these days. So it's become more of a prominent line of work. So I've focused on the defense industrial base, and we're talking energy security here. But I think there's going to be a lot of parallels between what we do in the DOD and what we're looking for and what we need in the energy sector. So the first bullet there is a definition of defense industrial base, I won't read that to you. I want to talk a little bit about what industrial base or supply chain risk analysis is. It's not really supply chain management, and supply chain management often focuses on designing a supply chain for optimization for efficiency. And that's a very important field, very important area. And there's a lot of research that's gone into that, and we do that well. Supply chain or industrial based risk analysis is identifying the risk and also understanding what happens when those risks are realized. So in the commercial world and in industry, for them, there's industrial base risk and risk mitigation; they are worried about what happens when things go wrong, right, and there's a lot of academic research—Gopi, I think is probably your area of expertise—and modeling the response to an impact to the industrial base or disruption to the supply chain. In the DOD, we are concerned with that, but we are also concerned about getting in front of the of the risk and understanding and predicting the risk with the DOD in the defense industrial base. So much of what we buy, I say we, the DOD, so much of what the DOD buys is very unique, very specific, low volume, typically. And the process of designing, qualifying the part and qualifying a supplier to build that part for you is lengthy and expensive. And so when we have a disruption to the supply chain, in the industrial base, or in the defense industrial base, it's a big impact and the recoveries are challenging, you don't typically just stop buying from company A and go over and start buying it from Company B or just go out to Amazon or Ebay and pick up your part, you know, so. So the DOD is very interested in getting in front of industrial base risk and mitigating or trying to identify and mitigate these disruptions before they occur.

Okay, a little bit about what's going on these days with industrial base resiliency. In 2017, there was an executive order that was released, and it was a whole of government activity too with the DOD taking a big role in it to understand the government's, the US, the health and security of the US, industrial base and supply chain. And then in 2020, as COVID was ramping up, the CARES Act came out, and there was about a billion dollars of it set aside to help identify and support parts of the industrial defense industrial base, to make sure that they didn't fail and potentially, you know, leave the market altogether permanently. And then

in 2021, there was another executive order this time on American supply chains, also whole of government. So DOD had a big role in that. And each of these executive orders are asking the government to go and do an assessment and understand what the industrial base for the supply chain or the health of the manufacturing is, and then come back with recommendations, then currently going through legislation or pending the chips act, you know, and this is a response. So the recognition that the US has probably gone too far in outsourcing or depending on foreign sources for its micro electronics, production capacity, and capabilities. So the CHIPS Act is out there pending now. And then I would go back and reintegrate that the COVID and the Ukrainian issues or problems have reinforced for us the importance of secure, resilient supply chains. And I would also say that, you know, the US government is investing heavily now, probably belated but nevertheless, investing heavily in understanding supply chains, and starting to understand what it takes to make them more resilient. Okay, so I'm going to tell you a little bit about what we do, and I think there's some pretty strong parallels between this and supply chains and industrial base in the energy sector. So sort of the premise here is that industrial base risk analysis is the foundation that undergirds a resilient industrial base, which is what we would like to achieve. So I'm going to talk about the things on this slide here a little bit individually and help you understand what the challenges are, and perhaps, you know, the applicability to the supply chain and industrial base for energy. So the first thing is visibility. And that's understanding your supply chain. And that sounds deceptively simple. In the case of the DOD, the DOD doesn't own its supply chain. It doesn't really, you know, build anything; it contracts it out, right. So there is some level of opaqueness between the DOD, the customer and its contractors—prime contractors who actually build and deliver the products that it's looking for. So if you would say, "okay, it's pretty easy. I'll just go to my prime contractors, and I say, 'tell me who's in your supply chain'", well, that's not quite as easy as that sounds; that's harder than it sounds, also. So one of the big challenges that we face is getting visibility into the supply chains. There's a lot of ways that we try to go about doing that. None of them are foolproof. And I think that's probably true in the energy sector as well. So there's a lot of effort and a lot of research ongoing now into how do I get visibility into the supply chain. Once I get some visibility in the supply chain, other thing that's very important to us, is to make sure that we are consistent in nomenclature and some other things, so that if I'm looking at the supply chain for the F 35, and I'm looking at the supply chain for something else, a stinger missile or an aircraft carrier or something like that, company A is known as Company A is known as Company A across all those, or component B is also known as component B is component B, because what I want to start to understand is, where do I have, say, concentration of a supplier? Where do I have some risks that derives from being overly dependent on any particular supplier or part? So visibility, once you get visibility, that's kind of the baseline for starting to understand where the risks are going to be in your supply chain.

Next thing is organization. That's kind of what it's talking about, you understand who the players are. And now I've got to put it in a structure. The next thing is collecting risk data. Probably not surprisingly to you, you can't just go out and Google and get all the information you would like to know about a particular company, right. So there's a lot of resources out there. But they're not perfect, and they're not complete. And that becomes particularly a problem when you get to the lower levels of your supply chain, which oftentimes are the ones that are producing some very niche, critical components for you. A lot of these companies are privately held. So the information you'd like to know about these companies and what they're

doing and who they're, you know, where they're getting their funding, or who they're selling to, or who's on their board, or who's you know, who's doing their design work is not knowable, because they're private company. So one of the things that we are working on is trying to find out, you know, what, what? What facts might I know that are publicly available that can serve as proxy data for me or give me indications of risk at the lower levels of the supply chain, on things that are not directly knowable? So that's the measurement piece of it. Then we get to the analysis, and that's kind of the fun part. Because then you start to try to understand. I've got my data here, I've got my models. And you know, where can I predict risk? What are the indicators of risk? Same thing kind of applies, though. There is no formula that says, "hey, if you get all these indicators, you know, a company is going to go out of business. It's going to get acquired by the Chinese. It's going to exit the market," or whatever. So you sort of aggregate all the risk data. You can put it in some models. You try to make some sense of it. And then you think this is a candidate for failure, or exit. And I'm going to go and investigate deeper, but there is no silver bullet that says, "if you see these things, there will be a failure," you know, so it's a pretty challenging thing to do the analysis, but it's, you know, it's interesting work. So let's say that we get to a shortlist of either companies or sectors or part types or components or something like that, that we think there exists a risk to our industrial base. Now, we want to start to prioritize those and say, "what do we know, which ones do we need to focus on?" Because you can't, you can't boil the ocean, you can't go fix everything. So you're going to try to figure out. Where can I have an impact? So that's the prioritization piece of it. And then there's the investment piece. And I think we could have a whole conference on investing in the industrial base, right? Because of the nature of what we're doing here with defense or energy, any type of critical technology, you can't always rely on an industry to make the investments themselves. A lot of times that investment is going to have to come from the government. And again, I said you could have a whole conference on how does the government invest in the industrial base for critical technologies without, you know, being accused of picking winners and things like that. But the US government does have mechanisms for investing directly into an industrial base and shoring it up and bringing it along to develop the technologies and deliver the technology that they need. So there's the investment piece. And then that kind of takes you into the mitigation. And then with any hope with me, with hope, with luck, you know, what you start to get now is a more resilient industrial base. You've identified where the risks are, you prioritize those, you've put some investments and invent and mitigations in place, and you start to have more of a resilient industrial base for yourself. And then you keep doing it, right, because it's a moving target. The technology is changing. The companies are always changing. So you never, you never finished the job. You're always looking for the next risk that's going to potentially impact you there. I feel like I should have asked for questions after that.

That was kind of a dissertation. So if I just totally lost you. Maybe you have to ask me later. So this is my last slide. And really, this, I'm not going to talk too long about this. But I want to kind of tell you, one of the things that makes our job a little bit different is just like I said, you can't go to Google and say, "what company, you know, is this company going to go out of business?" And we talked about getting visibility of the supply chain. If I wanted to know the supply chain for, you know, the Patriot missile or something like that, again, that's not out on Google. I mean, I hope it's not, right. I mean you hope it's not, right, that you can just go and find out what that information is. So that information typically resides, you know, within the DOD behind firewalls and secure areas. So if I want to understand the risks to the companies

that comprise that supply chain, I can't take the supply chain, and go hand it to somebody and say, "tell me what you know about this," right. But the data, the data that might be of interest to me, whether it's financial, regulatory, trade related, you know, any type of data about companies, that would give me clues, that's on the outside, right. So, so what we, the approach that we're taking, what we call the inside outside approach, we have the inside data on the supply chain, who's in it, what they're making, what they're doing with it, and then we bring data inside. We take outside data, we bring it inside, and we use that first part as sort of a framework tree, you know, and we start taking all this data and hanging it on there, and all the analysis takes place inside, you know, behind a secure firewall. So that's kind of the approach that we take. I don't know that that's directly relevant for energy. But I think there's certainly going to be components of our energy infrastructure and our energy supply chains that we're not going to allow to be out in the public domain. We may need to look at sort of the inside -outside approach for understanding the supply chains industrial base for our critical energy infrastructures. Yeah, and now I'm not going to talk about so that's, I'm going to, I'm going to stop right there. Again, just to kind of recap, industrial base: easier said than done. And part of the problem is getting the data, and then making sense of the data, and then validating that data. But I think there's direct applicability to the energy industrial base and supply chain. And I think there's a lot that we can do. Those two sectors can learn from one another. Thank you.

Dr. Gopi Munisamy: Good afternoon. Can you hear me? Thank you. Thank you, Justin, for that generous introduction. I'm reminded of a joke. Two economists interviewed for a job in Chicago, and one had a CV that had 100 publications. It was long, okay. And the other guy had five publications. And so the search committee asked the second guy," look at the other guy, he's got 100 publications, and you got only 5. Do you think you're qualified to be in this job?" And the second guy goes, "I have five different papers". Okay, so the long CV stuff is something that reminded me of that joke that I heard in grad school. I went to Minnesota for my graduate education. So we used to make fun of Chicago all the time. So, and thank you for the panelists for setting this up nicely for me. I'm not going to be talking about nuclear, all that stuff. I'm going to give you a very simple supply chain model in a very basic commodity. I'm going to show you the challenges on how that supply chain operates. Okay, so my objective is to give you a very simple, basic way of looking at supply chains, and we have shocks, you know. How do we go about looking at these shocks? Okay. So that's my hope today. And so I'm going to take a very basic framework in getting that information to you. It's going to sound like academics, but I'm an academician. This is a presentation where my students have helped me put some materials together. Some are right here in the audience. So you've heard supply chain, and you know what that means. You're starting from the base of a production and getting to the end point.okay, that's your supply chain. And you have a supply chain, starting from the production point to the consumption point. You can have multiple ways that system can be affected. In fact, the executive order where I copied this information from says defense, intelligence, cyber, Homeland Security help, climate, environmental, natural market, economic, geopolitical, human rights or forced labor are other contingencies. Okay, that's just the entire laundry list of potential risks and vulnerabilities that can affect the supply chain. Okay. And we have many examples. In the past four years, in particular, economists have been having a good time looking at all these deviations from normal. And the most latest one is the Russian invasion of Ukraine. But for two years, we've had COVID. And before that, I had a lot of fun. I'm basically a trade economist. So I was in the middle of the U.S.-China trade war back

in D.C. trying to manage a research program on trade policy, then there was this U.S.-China trade war. And then we also know about some of the human rights. Labor issues in the Xinjiang province of China. So we have many examples of late. So here's something that I thought I would shock you by throwing this at you. This is a supply chain. Okay. And one year, not even the entire supply chain component of it. This is just the amount of wheat, the basic food commodity that we all need, you know. You had a breakfast sandwich this afternoon, right? So this is just the wheat trade among countries. Okay. And somebody in Europe or North America would call it a spaghetti bowl. And somebody in Asia would call it a noodle bowl. Okay, that's how complex that whole thing looks like. And some of the red points are pretty big. You'll see the U.S. I don't know, I'm not sure if you can see all of that labeling in there. That's U.S., Canada—Russia is the one on the right, top right. Okay. And this is how flows happen. And this is like an output, not even talking about the input side of it, just the flow of wheat across countries. And so when this flow got disrupted, because Ukraine and Russia together accounted for nearly 20% of the production of wheat and 30% of global wheat exports. Okay, so you have a pizza, and you get four people, you know, all of us having your share of it, and you just take my share out of it. There's three more left, but four people competing for it. Okay. So there's going to be problems in terms of shortages. And what you see is the price increase for wheat. That's just right, mapped on the right side of it. Okay. So you immediately see the prices jump when you lose a share of the particular pie that you're talking about. Okay. And the effect varies within countries and across countries. In some countries like Egypt and Lebanon, they are rationing wheat. Okay, because there's not enough wheat, because they were entirely reliant on Ukraine and Russia for their wheat. Okay. If you go to a grocery store, you find the bread prices have gone up by $1–$2 lately, okay. So what we are talking about, I think many people talked about changing the supply chain all throughout the day. And so here is a very simple trade. In a very basic commodity. There's no technology knowledge, blah, blah, blah, involved. This is the basic commodity. And here I have circled China and Russia at the top. And then my second circle is around Indonesia, India, Pakistan and some of the other countries that have stayed neutral. Okay, now tell me how I'm going to untie those knots. Okay. And so this is a challenge we are talking about in a very basic commodity—that to take out some countries from supply chains and replace them with some other countries is not something that's going to happen overnight. Okay, it's a process. Okay? And trying to isolate those guys that didn't take a side, you know, in this war, okay, it is going to create another supply chain that is in South Asia and Southeast Asia. And that's not going to get us anywhere either. I can't even identify the knots to separate them out.

So I also have an agricultural economics training. So I gotta put this out for you in front of you that we don't produce the same kind of wheat everywhere. Okay, if you know the wheat market, you know that—something called hard red hard when a spring you know, you know, and soft white, all sorts of—there are six classes of wheat. And different countries produce different types of wheat. And each feed is used in a different story, you know, for bread, a different type of wheat, for cookies, something else for noodles, something else or pasta or something else. The pasta is the one most expensive; the durum wheat is used in pasta. Okay, so if you're, if you take this output supply chain, and layer it with the input side of things—what type of wheat and what type of users—you can see a three dimensional spaghetti. Okay. And I thought I'll put this in for you, because you're all focused on energy today. This is from the DNV energy transition outlook, and this picture doesn't look any different than what I showed you. On the other side, it is the various sources of energy—coal, oil, crude oil, coal,

believe natural gas, biomass, solar, thermal, all that stuff—how they pass through, and what the end users are, or aviation rail manufacturing, blah, blah, blah. Okay. So this is not a country space, this is a product space, how certain products get transitioned to certain users, okay? Now, what we want is these thinner lines at the bottom, okay, to get thicker, and thicker lines at the top, get thinner. That's the climate change mandate—that we move away from fossil fuels and into, you know, more renewables and maybe nuclear as well. Okay. And you can imagine the complexities of it, given the knowledge and the technology base underlying each of these, compared to the VT story I told you. Okay, so you can compare and contrast the energy story with the wheat story. So what I'm trying to say is, this is an enormous country. Company dimension, that we'll talk about, resource type, use all those challenges; it's a huge challenge. Okay, altering a supply chain is a mega effort. Okay. And so there are things we can do. Okay. And I'll give you an example, going back to the chart, but I'll just want to quickly review what I've seen in the context of supply chains. The executive order that we talked about earlier, 14, or one-seven, that came out about a year and a half ago, from the White House, asked major Cabinet departments to come up with assessing vulnerabilities in their particular segment and tell us what the solutions are. Okay. And based upon that, they've initiated a few solutions to them, including some public-private partnerships. And, as I think, as both Rob and Will talked about, we don't know what the companies are doing. Okay, we hear from them, that they're going for a less than global supply chain. Okay. We are used to a global supply chain, but we are going to a less than global supply chain, but I'm not even sure I see the data or the numbers out there. Okay. In some cases, as in the case of uranium that we just saw, okay, is it even possible, okay, to have a less than global supply chain. And I think Justin talked about it this morning as well, multilateral institutions, okay. In the past five, six years, we've sidelined them. And as a trade economist, I've been sad to see the World Trade Organization has its problems, but it has been sidelined in terms of dealing with conflicts. The best example being U.S.-China trade war, which happened completely outside of the WTO purview. Okay. But can we do something about it? Can we revive them to have some teeth and bring about some changes to address these challenges? Okay, so I don't want to take too much of your time. The road ahead is challenging. I don't want to leave you on a pessimistic note, but it will require large and sustained investment if you're going to move parts of the supply chain and reconnect them someplace else. Okay, so this is just an academic viewpoint, and I'm happy to take any questions.

Conrad: Well, thank you, to all of our panelists. There's quite a bit of food for thought there from all aspects of this question. So I've got maybe one or two questions, and then we'll just move right into audience Q&A. To start things off, I know that you came all the way here because you wanted to talk about the pandemic. And I know you haven't talked about COVID−19 enough over the last couple of years, but I think it's something that's very relevant here. The striking thing about the pandemic for, me, was from a consumer perspective, just how acutely aware all of us became of the sensitivity of our supply chains across sectors. What, how there had to have been some lessons learned in terms of securing supply chains. What have we learned from the pandemic that we can apply to securing the chains for our energy infrastructure? And I'll leave that open to whoever wants to jump in.

Cook: So well, okay, I'll state the obvious. It goes back to what I said on the chart visibility. I think you've got to know because I think when the pandemic happened, and things just kind of locked down, you couldn't get things in. You couldn't get certain end products. And then you started understanding why can't I get this end product? And you find out oh, three, four, or

five tiers down, what I really need derives from China or someplace that's locked down. So I think one of the things that we learned about from COVID is visibility. The other thing that I would say that we have learned is that we've tossed around the word resiliency a lot. And that's very important. But you know, resiliency is kind of a vague term. And so how would you achieve resiliency? So I think one of the things that we learned is we need to think about resiliency. And you could toss out a lot of things, but one of the things I would put out is redundancy. And I think that kind of gets to what Gopi was talking about, you know, if we are solely dependent on one country, or one region or one supplier for anything, you're vulnerable. So I would say resiliency, but going a little bit deeper than resiliency, redundancy is one thing to think about.

Sweeney: I think the single point—vulnerability is a major concern. Particularly in the nuclear business, there might be just one person, if you can't get that component, you might be shut down for a week. One week is five to $15 million, depending on what site you're talking about. So these are real, these are real stories. The other thing, to flip it around, though, in a positive way, I think people learn to work differently, virtually. And so it brings, I think, a faster resolution in many respects, than the old fashioned way. But also it does bring a challenge. And I think there's been technology developed to help do that, to share in data rooms, where you would not share in data rooms before. So in some respects, it was a negative. But it turned out to be a positive where we found we're much more efficient. And we found technologies weren't there, but now they are, and we don't need to do things the old fashioned way. So I think digitalization has really helped in this particular capacity.

Munisamy: One thing I think is the importance of people, just the people, you know, whether you're in a country that has a lot of capital, machines, automation, versus a country that just relies on labor. Regardless of where you end up across countries, you just need the people, whether it is science and technology, people developing vaccines, or a port worker, just moving a commodity out of you know, Savannah, from one of the docks into the ship or vice versa. The human ingenuity was something that I was really impressed with.

Conrad: I also want to seize upon the discussion that happened here towards the end, a little bit about this. What did you call it less than less–than-global supply chain? And I think when we use the term resilience lately, it seems to be kind of a codeword for domestic sourcing, in a lot of ways. And so I was wondering, I'd like to hear from you guys. Just how realistic you think that is? I mean, looking at the your graph regarding wheat. It doesn't look very realistic to me. But is there use in the U.S. government pushing some kind of "buy American" program to secure our supply chains?

Sweeney: Some of the things we were thinking about in the United States in this, sitting on the civil nuclear trade advisory group, is to get to this point to not have to rely on certain countries. And so there is a move to get more domesticated supply chain sourcing. It's not easy, because it takes, as I said earlier, it takes a policy shift. Maybe it takes investment. And quite frankly, if it's not innovating, people are reluctant to put money into it, or time and effort. They'll go someplace else. And so I think, yes, we want to buy American, yes, we'd like to put money in. But if it's a one-off, it's not going to happen. So they need to see a demand. And that's, in our particular case, we've been talking about it for years. Show an order book, and things will completely change. We need to see this more than just a one-off. Or it's just to placate a particular industry, where we really can get it someplace else. So if we can't get it from some-

place else, just make sure it's a solid source, and that you have established some relationship, and you have a long term allied relationship. And the bigger these projects are, the bigger the components are. And if we're talking reactors, it's a big deal. And so we will not be buying Chinese reactors in the United States.

Munisamy: One, if you go back to the spaghetti bowl that I showed you, there's an incentive for people to give up on Russia and buy from you. That is, if I lower my price, like if I'm the U.S. the producer and I want to lower my price to a point where we can just completely forget about Russia, okay, in a way that we target the price that is lower than what Russia is offering. Okay, then I don't have to worry about untying the knots. People automatically are incentivized to go pick up from me versus Russia. Okay, so we can untie the knots. But you need the incentives. And that's where I'm reminded of a CEO of a cell phone company in the 1990s. That said, when people were told you could have a phone that you can take with you as you walk, and you can talk to anybody when you want to. Everybody jumped at it. Okay. But if you walked into the CEOs office and said, "I'm going to change the bulb for you." It's going to look a little bit different, but you will make the money in 30 years. Okay. There is no incentive. We talked about the consumers this morning. So where is the incentive? Okay. And if you have the right incentives, you can make this change happen. And the right incentive can come through policies as Rob talked about.

Conrad: So if the demand is not there organically at the moment, and there needs to be some kind of strategic thinking from a policy perspective, Will, what role does DOD and the defense industry potentially play in driving that demand?

Cook: Yeah. Well, so I would, I would say, you can—you the DOD—can mandate "buy American", and it does. But I would go back to something we said earlier in the day. I wouldn't tie it down to just buy American. I would say "buy trusted", right? So we fear allies, you know, the Five Eyes or somebody like that, because, you know, the U.S. can't do everything internally. So if you cast a slightly wider net, could the DOD or could the U.S. mandate it? Yes, it can. Does that work very well? You can end up driving up your costs. So I think if you want to achieve that, and I think in certain areas, you know, for critical defense and maybe critical energy components, you do want to force a "buy American" or "buy trusted," you can just make the mandate out there. But I would go back to what both these gentlemen have said—the incentives. I would look for innovative ways to put incentives in place for the right companies in the right countries to give you what you want in a competitive environment that's going to help keep the cost down, keep the quality up, and the innovation up. So I think just a brute force "thou shalt" through the regulation or statute is not going to serve as well. So I think it's a time to be innovative.

Sweeney: Yeah, I would just add to that, particularly like in the utility business, they like to have at least three bidders, right, for that competition. So if you start directing, it has to be—you're limiting your options, potentially, that means you're going to pay a higher price, not necessarily getting any guarantee of higher quality, and also, from a security standpoint, one of the things you need to be very careful about is the subcomponents. And these things could be assembled from all over the globe. And yeah, you might get it from a US vendor, but you find out he's used parts from China, and it's using unqualified materials, you find out it breaks on flight, different story tomorrow.

Conrad: I think with that, we can open it up for Q&A from the audience, if anybody has a question. Dr. Gattie is really excited.

Gattie: So thinking in terms of Mountain Pass, what I'm thinking about here Mountain Pass and what we at one time could do back in the 80s, I think we were supplying—processing even—most of the world's rare earths. My question is, how long does it take to restore that legacy position that we had in mining and process and rare earth metals? What was the timespan here, or any feel for that?

Sweeney: Materials. That's the key, because there are places in the United States where we won't find any of the certain things. But at the end of the day, we could go back in time. But if you take a look, and I think I've shared some charts with you, David, before, the Chinese have been gobbling up everything all over the globe. And we do have limited materials in the United States; we don't have it all, so I think we're kind of stuck. We need to realign, I think, our geopolitical relationships, and trade relationships, and open up dialogue where we might have shut off years ago. But really look at the whole system just like your model does. You're looking at who's using that material. Where's it coming from? And I think we haven't done enough of that. And I think that the Chinese have watched us do nothing and have gobbled up a lot of the resources and governments that control those resources.

Munisamy: But at what cost, do you want to do that? At what cost do you want to do that?

Gattie: Now, See, I'm asking the question. My real point was, can we recover back? That was really, or to Rob's point, is China so far out in front of us that we're going to have to look to allies to have a 21st century supply chain around those elements?

Munisamy: Yeah, my thinking is, if the price is $100,000 versus $1,000, it's never going to come back. Okay, China's going to give it to you for $1,000. Okay, and we won't be able to make profit out of it. But like Rob said, we have to find allies who would work with us that not only you get it cheaper, but also make it stable. I think that's the kind of supply chain we're looking for and calling it resilience.

Sweeney: The DOE is trying to spend money in this area, of course, and maybe some of this. And they're also looking at synthetics, so they're looking to spend a lot of money to even make this stuff back up in synthetic form. So, to me, I'm not sure if that's economic versus going to partners and retooling our relationships and doing a better way and having a more secure way. Because I just don't have that much faith in our government these days sometimes.

Cook: I know a little bit about the project, right. But I would never underestimate the American ability to develop an industry and put a product out, given the right incentives. You know, it always comes back to that word, we keep saying incentives. But just by way of know, the Mountain Pass, that is actually a beneficiary of some of the government investment that I was talking about earlier. There was a thing called the Defense Production Act, Title Three. And that allowed government money to flow into that. So that's a combination of government funding going into Mountain Pass and some private and a lot of private investment going in there. And so the government in this particular case is trying to set the stage by helping seed some demand. They're going to say, "Okay, we, you know, we need this. There's going to be some demand out there." They're providing some capital, and they're giving the company the ability to go and work this. So will it succeed? I don't know. But I think, again, given the right

incentives, it very well could. Could it reclaim all that we had? Could we supplant China? No, it's not that big of an operation. Could it give us what we needed in for, you know, for a critical supply? Yeah, I think it could.

Audience: Hello, I would like to ask, is there certain technologies that we like for them to stay kind of vulnerable in a supply chain, I'm thinking of semiconductors in like, in regard to Taiwan. So I'm thinking if Taiwan is to lose its, like, large share of global semiconductor production, that they become more expendable towards the US, and may become like, less of a security prioritization. Same thing with the Middle East, as countries move away from oil. They may experience an increased pressure to act more irrationally as they lose their kind of fallback position economically. So yeah, I'd like to hear your thoughts on that collectively.

Cook: I think I understand your question. Let me just read back to make sure I did. You know, do we? Do we actually want some vulnerability because it strengthens our ties? I'm not able to answer that question. I'm kind of a supply chain nerd. So that's a diplomacy and policy question out of my out of my depth. So I would be remiss if I tried to answer it. It's a great question. It really is. But I'm not equipped to answer that for you. I apologize.

Munisamy: I think I can give a response. If your economic objective, if you only have an economic objective, you know, obviously, but if you have political and economic objectives, yeah, there might be a reason why you might want to do it. Okay. As economists, we always work with this function stuff, you know, profit function, you know, utility function, and so on. So there is a political economic function out there that you want to maximize. Yeah.

Laredo Loyd: Hello, everyone. First of all, I want to thank all of you for being here. It has been really insightful. This question kind of goes back to what Mr. Cook was talking about earlier and also touches on what I want to ask. It's more of a general supply chain question from the production side. So, yesterday, there was a Senate Armed Services Committee meeting where they discussed the vulnerabilities we have in our defense industrial base. And a big part of that is how do we maintain demand without constant input. So, for example, with our Stinger missiles, we have given more to Ukraine this year than we've manufactured in the past 20 years, just because there wasn't necessarily a demand for it. And I think this is also something that applies to the entire energy security issue. We've fallen behind in a lot of our energy security R&D, whether it's nuclear or otherwise because there isn't necessarily a demand for it. We're meeting current demand, but now the demand is shifting towards renewables and addressing climate change. So, within both national security and the energy transition, how do we basically create artificial demand that keeps the production side of the supply chain active? How can we keep those production lines hot so that they can constantly be producing, as opposed to, say, with our Stinger missiles, where we have to wait a few more years before we can get the production lines active again? So, how can we do that both on an energy capacity and industrial base capacity?

Cook: Well that's the million dollar question. I didn't see the SASC testimony yesterday. But I can tell you, it's a known problem. So there's a couple of things, not a couple—here's some things that the DOD is trying to do. One is to aggregate demand. So that the Army, the Navy, the Air Force, instead of buying individually, they're aggregating demand, and then they're trying to get a picture of what that aggregate demand looks like. And then they are trying to, you know, help industry understand what that demand signal looks like. That's, that's one thing

that's sort of on the technical side. On the political side, it gets a little bit more dicey, and part of it is a just the vagaries of defense budgeting and the budgeting process in general. So the government publishes a five year budget. Year two does, you know, next year, your year one doesn't look quite like last year's year two, right? It's always changing. So that's what industry would come back to government and say is, we need a clearer picture of what the demand is going to be. And I don't know the solution for that, you know, but, you know, recognize that that's one of the things that we could do. And then there exists in particular areas within the DOD, particular sectors, you know, of products and stuf. They do a pretty good job of understanding the inventory, understanding the demand, and trying to aggregate that demand, and then they're able to take that data and run some, you know, support F drill, some sensitivity analysis, where they model in a disruption of what like, what Gopi's talking about. And try to understand, hey, if this happens, you know, if we go to war, and there's a huge demand for, you know, for Stingers or Patriots or whatever it might be, what does that do? And what would industry's response profile look like? So there's some modeling there. So that gives us some idea as to how they might address it. So not a good answer to your question. But just I would say that it's a known problem. And these days, there's a lot of effort going into addressing that problem.

Audience: [INAUDIBLE]...the question of to continue the process after subsidies. For example, when COVID started, there was a question about masks for healthcare providers. And China was effectively importing the masks [INAUDIBLE] And so we were not able to have masks and that was a major issue, because healthcare providers were exposed to infection. And so we put a lot of effort into developing infrastructure to build our own masks. And there was a lot of suffering to do it. And we were able to do it, but your challenge is to get improvements for that, right, to do that in our own source, for these critical masks. But now, what's happening with my understanding is that, effectively, it just all goes back to the status quo. So we put effort, I can say the veracity build the capability to read reality is okay, we've done that, but that bottom line is okay, but I can get 20% us from China. And I'm going to do that. So it feels to me like there has to be some mechanism. There are some critical things to invest in initially. And then we sort of forget. But wherever it is, they're investing, figure out some mechanism to deal with, you know, the attitude of incremental cost; it's driving back.

Munisamy: When you have a pandemic, or when you have a shock, prices get out of proportion to the normal, long, long-run trend. And then you have incentives for high-cost producers to enter the market and make profit out of it. Okay. But once a shock wanes, okay, you're back to a normal trend. Now the price is low; the high-cost producers have to exit. That's the global economics of how we operate. But the only way to stop that from happening is we put tariffs on China's masks. We put tariffs, okay. After the process has ended, we still want to sustain our industry. And so we say we're going to put a 30% tariff on it because Chinese masks our $1, ours is $1.30. We're going to bridge the gap at the 30% tariff okay. We can do that, but that means we are going to sustain an industry and pour resources in it, which could have been useful in semiconductors, nuclear or something else, and so on. So, is it worth it? Okay, and turns out people generally don't like to do it once that thing goes away, because there is no incentive to keep it.

Munisamy: The talk about—the recent talk about supply chains is not just the price story; they want the stability part of it, and that's why they call it resilient supply chains. And I do believe, cost

and stability can be together to create a supply chain. I think, you know, there was an article by Li Xi in the Harvard Business Review that talked about these resilient supply chains. One could think of North America, along with Mexico and some of the Central American countries, having the range of labor you need to produce all sorts of goods. A supply chain that just encompasses this region might be independent. That would be low cost, as well as stable. Likewise, Europe is being thought of using Eastern Europe and Northern Africa and creating its own supply chain with a variety of skilled labor, doing various things and being self-sustainable. So resilience and low cost can be built together, but then, rather than have a global system, you're going to have piecemeal systems. Okay. And so we're going to pay some price to do that. And is that worth it for the stability that you're asking for? If you ask the politicians now, they'd say yes. Okay. But like you just gave that example once the situation goes away. Obviously, you've got to say yes. And I don't know.