UNIDENTIFIED SPEAKER: We’d like to take a few minutes to explain the Long Duration Storage Shot. The Long Duration Storage Shot plans to reduce the cost of storage systems that can deliver 10 plus hours of electricity by 90 percent by the end of the decade. This 90 percent number is based on being able to store and deliver or charge and discharge a kilowatt hour of electricity for less than five cents. What does that mean for everyday electricity users? To understand the Storage Shot goal, it can help to describe what a kilowatt hour costs and what it does. In round numbers, a kilowatt hour usually costs about 10 cents from your local utility. Like gas prices, it could be higher or lower, based on where you are in the country, time of day, or season. Inside your home, a kilowatt hour can bake a pizza or power your television for 20 hours. On the go, one kilowatt hour can charge a smartphone 100 times or allow you to drive an electric vehicle for three miles. It turns out, 10 cents can really get you places. The lowest cost electricity most often comes from renewables like solar PV. A 2030 price target for DOE’s SunShot program is five cents per kilowatt hour for rooftop solar. That’s cheaper than most electricity costs today. A problem with some types of renewable energy is that the energy they create isn’t always available when people need it. Solar is available during the day, but people need to use electricity at night. Storage fixes this problem. During the day when people may be outside, electricity from the sun gets stored in a battery. At night, this electricity can be released to allow you to cook, read, surf the Internet, or watch TV. With 10 or more hours of available power, that’s plenty of juice to finish everything before bedtime. The Storage Shot goal has a simple target. We want to make clean electricity available day and night that’s competitive with today’s prices. Specifically, Storage Shot technologies will be able to move electricity from day to night for less than five cents a kilowatt hour. If we can achieve this target, then we can slim down our target footprint without slimming down our wallets. To recap, the goal for the Storage Shot, DOE’s second Earthshot, is a dramatic reduction in energy storage costs so you can chow, connect, or binge, no matter how strange things get outside.

MEREDITH: Ladies and gentlemen, good morning and welcome to the U.S. Department of Energy’s Long Duration Storage Shot Summit. We are so pleased to have all of you here with us today. I’m Meredith Braselman with ICF, and our team will guide you through today’s session. First, a few housekeeping items as always. Please note that this WebEx is being recorded, will be posted on the Department of Energy’s website, and may be used internally. If you do not wish to have your voice recorded, please don’t speak during the call. If you do not wish to have your image recorded, please turn off your camera or participate by phone. If you speak during the call or use a video connection, you are presumed to consent to recording and use of your voice or image. If you have technical issues or questions, you may type them in the chat box and select to send to our host. We have muted your lines upon entry, and we will remain muted for the duration of the webinar. If you need to view live captioning, please refer to the link that will appear in the chat or multimedia panel. For optimal viewing today, please click on the layout at the top-right corner of the viewing screen and select grid so you can see all the speakers at once. Please note that some of the presentations today are prerecorded. If you have chosen to join us via your phone, you may not be able to hear the audio. However, we will be posting these videos to the website following the event. And then finally, any technical questions or issues, please type them in the chat box and send to your host. Now, to get us started today, we have some polling questions for you. We’re going to keep the polls open for the next few minutes, so please go ahead and fill them out for us. And now, I am really pleased to welcome Pat Hoffman, acting assistant secretary for the Office of Electricity at the Department of Energy, to get us started. Pat, I will hand it over to you.

PAT: Thank you very much, Meredith. And I would also like to express my warm welcome, and good morning to everybody here today. Welcome to DOE’s Energy Earthshot. It’s the Long Duration Energy Storage Shot Summit. As everyone here knows, the Long Duration Storage Shot was announced on July 14 by Secretary Granholm and sets an ambitious target of a 90 percent reduction over the next decade. Today’s summit brings together a wide range of stakeholders and leaders from industry, researchers, entrepreneurs and users, regulators and students interested in long-duration energy storage and how we can work together to achieve this goal and create affordable grid storage for clean power anytime, anywhere. As part of this event, guests have been able to dialogue on technologies and other opportunities to advance long-duration energy storage. Engagement with all of you on long-duration storage technologies is crucial for us as a community to be able to identify the key challenges and bring down long-duration energy storage costs as well as develop strategies to address any issues within the decade. Today is also critical, as world leaders in energy storage also met yesterday in the World Energy Storage Day to advance energy storage technologies and applications around the world. I was able to participate yesterday on a prestigious panel of experts and discuss the U.S. and international opportunities for energy storage. So, today this summit is an important start to the U.S. dialogue engagement as we look forward to building on today’s discussion to achieve the Long Duration Storage Shot over the coming weeks, months, and years. I know the capacity for advancing energy storage is strong, and there is definitely a lot of energy here to make a difference. So with that, I would now like to introduce today’s moderator for the plenary, deputy secretary of the U.S. Department of Energy, David Turk. Prior to his return to DOE this year, he was deputy executive director of the International Energy Agency, where he focused on helping countries around the world tackle their clean energy transition. And during the Obama/Biden administration, he coordinated international technology and clean energy efforts at DOE, including the important work of spearheading the launch of the Mission Innovation, a global effort to enhance clean energy innovation. Welcome, Deputy Secretary Turk.

DAVID: Well, thank you very much, Pat, for the introduction, and thank you even more importantly for all your incredible leadership of the Office of Electricity here at the Department of Energy for many, many years. Thank you to you and all of our colleagues here at the Department of Energy involved in this Earthshot. And let me welcome everybody to this first summit of the Long Duration Energy Shot. Let me provide a little bit of context for our discussion today. As I hope everyone who’s paying attention has seen, it’s through no fault of effort on our part in this administration, we’ve got incredibly impressive, aggressive, ambitious targets on climate change here in this Biden administration. By 2030, we want to get to 50 to 52 percent reductions; by 2035, clean electricity; and then by 2050 we want to get to, we need to get to climate science, and what we’re seeing around us says that we need to get to net zero by 2050 time period. These are incredibly ambitious goals, and to be successful on those goals, we need to do two things fundamentally. One is we need to deploy existing technologies. Those technologies whose costs have already come down in the marketplace and being utilized. We need to deploy, we need to deploy, we need to deploy. We need to get those technologies out there with a pace and with a scale. And then secondly, to get to net zero throughout our economy, not just on electricity but on transport, on buildings, on industry, we need some new technologies, and we need to reduce costs of key, key technologies like today’s subject: long-duration energy storage. And this is the birth, this is the impetus for the Earthshot for the Department of Energy and the U.S. government. What are those key technologies whose costs we need to dramatically reduce so that we have the tools in the toolbelt that we need in order to get to that net zero goal by 2050? And storage, long-duration storage in particular, is one such key critical technology, and that’s the subject of what we’re doing today. Now, this is not just for show, this is not just an announcement with no substance behind it. What we’re doing at the Department of Energy is spending over one billion dollars a year throughout our Office of Science, throughout EERE, our Energy Efficiency and Renewables team, throughout Pat’s team in the Office of Electricity, ARPA-E, all the levers, all our national labs that we can bring to the table, trying to work seamlessly across this platform to try to drive those costs down 90 percent on long-duration energy storage. Incredibly ambitious, yes, but incredibly necessary, and I know we’ve got the team that can get that done. We also have a phenomenal opportunity with the President’s Build Back Better agenda that’s pending in Congress right now for additional funding, additional tools, additional authorities that can help on the grid and help on storage in particular. One example of that is in the bipartisan infrastructure bill. Sixty-five billion additional dollars for grid resilience just in that one part of the President’s agenda. In the reconciliation bill there’s a clean energy performance program that’s being discussed right now in the House and in the Senate. That would be a huge, huge additional motivator to get these technologies out there at scale. Now, one personal observation on this particular Earthshot on long-duration energy storage: I was just in India a few weeks ago meeting with ministers who are focused on their 450-gigawatt target of renewables and rolling that out—a big, big deal if they’re successful. The minister said again and again, and this was actually several ministers told us this, storage, we need storage, we need storage to be a critical part, and they’re looking at us, they’re looking at us in the Department of Energy, looking at us at our national labs, looking at us at that are entrepreneurs in the U.S. to drive those costs down. And so, I think there’s a responsibility on us here to really step up and drive this technology and to reduce those costs. Before getting to our speakers, two exciting announcements from the Department of Energy. First, DOE’s Advanced Manufacturing Office is awarding $17.9 million across four projects aimed at addressing key manufacturing challenges with flow battery technologies. These technologies can offer long-duration storage for grid scale applications and boast lengthy productive operating lifespans. I understand some of our awardees are tuning in today. So, let me offer my hearty congratulations on behalf of all of us in the DOE and the administration and my thanks for your work to improve our ability to store and dispatch clean energy from renewable sources on a grid scale. The second announcement, exciting announcement, is our Energy Storage for Social Equity initiative from DOE’s Office of Electricity. This is a $9 million program focused on helping communities assess opportunities to leverage energy storage as a means of increasing resilience and lowering energy burdens. If you’d like any additional information on both of these announcements, please go to our website to learn more. All right. Now on to our keynote speakers for this session. The first speaker was supposed to be Gina McCarthy, our National Climate Coordinator. Unfortunately, Gina’s been working so hard and so tirelessly she is not available to join us. She’s a little sick today, which with her schedule and what she’s doing, I’m not sure how she’s not sick every day, just given the demands and the wear and tear on her time. Gina’s a personal hero of mine. She’s doing phenomenal work in the White House on our behalf. So, we pass along a hope that she recovers very, very quickly. We do have in her stead Gina’s right‑hand person, maybe right‑hand person and left‑hand person, Ali Zaidi, who’s Gina’s deputy. I suspect many of you have had a chance to work with Ali before. He was such a critical part of the Obama administration in the Domestic Policy Council and also at OMV, which is an incredibly important and powerful part of the government that doles out the funding and works on the management side as well. Ali’s worked in New York state, helping them get their act together on clean energy efforts. He’s worked at Stanford previously in a variety and depth and breadth of experience on this front. The world, the U.S., all of us are incredibly lucky to have Ali in the position he’s in, and he really is at the nexus and the hub of all things climate, all things climate strategy, policy, and technology coming from this administration. So, Ali, let me turn it over to you for your remarks.

ALI: Thank you, Mr. Deputy Secretary. And my two takeaways from the intro are, one, I should work on being ambidextrous so that I can be the right hand and the left hand, but two, maybe I’m working a little less hard than my boss and I should pick up the tempo. Look, it’s really great to be part of this gathering. This work could not be more important. You know, I grew up in Northwest Pennsylvania and was surrounded by these grain silos that during the wintertime were a meaningful form of smoothing the consumption of the grain that was grown in our communities. I think it’s really fitting that the modern grain silo was actually invented in the late 1800s in Illinois and that we’ve got a son of Illinois emceeing today’s conversation about how we have that next revolution that will be spurred again by technology that’s built and invented here in the heartland and will help advance our economic success and literally improve folks’ lives. The way we think about the role that long-duration storage plays is really an enabler of the big bold ambition that the President has laid out with regard to clean energy. And, you know, when we think about the President’s ambition trying to get to 100 percent carbon pollution-free power, we know that 24/7 power is going to be a critical element of that. Folks count on their power to be reliable, to be affordable. And increasingly, folks count on that power to be clean. And as we look at different parts of our economy, whether it’s the building sector where electrification is underway or the transportation sector that is shifting increasingly to electric vehicles, the President’s got a bold goal there of 50 percent new sales being electric here in the United States. That grid becomes not only the means through which we decarbonize the power sector; it actually becomes the means through which we decarbonize industry and buildings and transportation. So, this inventiveness that the Department of Energy is marshalling today, and I’m so thrilled to see deputy secretary bring that same spirit of sending moonshots out of this planet to dealing with the greatest challenge that faces this planet in the context of storage. So, we’re really excited. As the deputy said, the Build Back agenda, Build Back Better agenda is really designed to accelerate and harness the opportunity that’s here, but really, it’s going to be our technologists, our inventors, our engineers, folks working on factory floors who are going to help us drive down the costs in this ambitious way, 90 percent. That’s going to be a critical enabler for the grid. It’s going to be a critical enabler of decarbonization for the entire economy. It’s what’s going to propel job creation competitiveness here in the United States. It’s going to help rural communities and urban ones. So, you know, in the 1800s, it was the grain silo. Right now in this moment, it is taking that same bounty from the sun and the wind and putting it into storage for electricity, using it when we need it. So, really grateful to be here with you guys and just thrilled that this work is happening.

DAVID: Well, thank you very much, Ali, not only for your incredibly eloquent and passionate remarks, but more importantly for your tireless, passionate dedication to the cause. And having worked with you for many years, Ali, and traveled with you recently to visit our National Renewable Energy Lab, I can attest to the fact that Ali is working incredible hours on behalf of all of us. So, thank you for that, Ali. It’s too good of an opportunity, Ali—before letting you go, I’d love to just ask you a quick follow­-up question. It’s a more generic question than long-duration storage—but you can certainly bring that back in if you like—is we see the IPCC reports, we see the various scientific analysis going out there. I think for many of us who are passionate about climate, it can sometimes be discouraging, right? We’ve got so much work to do in so many different sectors in such a short amount of time. I’d love to ask you fundamentally what gives you confidence that we’re up to the task? What should make us optimistic, not in a Pollyannaish kind of way, in a real-world kind of way? And of course, just as you laid out, the President has been so eloquent on this, and Secretary Granholm. It’s not just a climate imperative; this is an opportunity to reinvent communities, to empower our communities. Jobs, jobs, jobs. But what gives you confidence? What makes you optimistic?

ALI: A few things. One, I remember sitting in the office actually right next to where you are when a few folks were huddled around Steve Chu’s coffee table talking about the SunShot and driving down the cost of solar. And I remember when we were talking about it, the, you know, really, really brilliant technical folks who had been watching the trends in the market were skeptical we could make it there. And we ended up having this conversation about Bell Labs and the history of the United States always conquering what’s seemingly unsurmountable. And, you know, we hear it every day from the President, who I don’t think could have a stronger belief in America’s ability to take on these challenges. So, thing number one is just I think there’s proof in the pudding. America has set goals and we have achieved them. That SunShot goal, by the way, we achieved ahead of schedule. DOE had to set a new one to go even further and faster. So, that’s thing one. Thing two, you know, in the time before I came back to government service, I actually had the opportunity to teach some emerging STEM students, and the inspiring thing is we’ve got hordes of talent that is waiting to be called into a national mission like this. The work that the department is doing when we set big goals like this is really to put a big bright beacon out there for our most talented folks to step up and take on this challenge. And the last thing I’ll say is, you know, we’ve got an advantage here that we know how to build these technologies. We’ve got the factories and the workers that are the most skilled in the world. Give them the technology; give them the breakthrough. They will find you cost reductions even in the manufacturing of it, and they will deliver. That’s what we’re seeing. You know, you look at the electric vehicles that are being put together by United Auto Workers here in the United States. You got your electrical workers all around the country that have been on the frontlines of advancing this innovation. Our innovation system doesn’t end at the National Labs or at universities. It ends with the workers who are harnessing these technologies. And to quote Dave Turk from five minutes ago, deployment, deployment, deployment. And that creates jobs and jobs and jobs. And maybe that’s the last thing that I would say gives me hope. The economic prize is so big, so, so big, and it’s an economic prize that can actually fall along a distribution spectrum that brings justice to communities that have been too often left out and left behind. So, that’s what gives me hope, and I think we’ve got the track record to succeed here.

DAVID: Well, thanks, Ali, and thanks for your tireless dedication and for coming back into the U.S. government. All of us are in much, much better shape with your leadership. So, I appreciate everything, Ali, and thanks for joining us today.

ALI: Thank you.

DAVID: All right. Let’s move on to our next speaker, Senator Susan Collins, who’s the senior senator from Maine. Senator Collins has made sure that Congress supports next-generation technologies key to our clean energy future, including storage. Two years ago, Senator Collins teamed up with Senators Martin Heinrich, with Tina Smith to pen the Better Energy Storage Technology. And every bill on Capitol Hill has to have an acronym, and if you spell out Better Energy Storage Technology in acronym form, that’s BEST, the BEST Act. And she worked with Congressman Foster in the House, who we’ll hear from in a few minutes, to shepherd this onto the President’s desk for signature last year. The BEST Act provided a comprehensive strategy for advancing long-duration energy storage systems, and this Storage Shot will help bring that bill, that strategy to life. Senator Collins, over to you.

SUSAN: Thank you for joining in this important conference. Let me begin by commending the Department of Energy for working to accelerate our nation’s transition to cleaner energy through its Long Duration Storage Shot initiative. Energy storage technology holds great promise in the fight against climate change. Advancing next-generation energy storage will allow us to integrate more renewables such as wind and solar, which in turn will help to reduce harmful emissions. That’s why I authored the Better Energy Storage Technology Act, which became law last year. The BEST Act seeks to boost U.S. research efforts to promote advancements in energy storage technologies. It’s exciting to see the department begin implementing this new law through the Long Duration Storage Shot. This initiative will help to reduce the cost of energy storage technologies, improve the efficiency and resilience of our electric grid, and bring us closer to a clean energy future. Clean energy is vital for our economic growth, the creation of good-paying jobs, and, of course, protecting our environment. The great strides the energy storage sector has made are exciting. I hope that the public and private sectors can continue to work together to accelerate this vital transition.

DAVID: Well, thank you very much, Senator Collins, not only for your words, but for all your tireless leadership, including on energy storage. Our next speaker knows a few things about big bold achievable goals for decarbonization. It’s a pleasure to welcome Audrey Zibelman, who spent 30 years working to build cleaner, more affordable, more reliable power systems on multiple continents. She served as a utility executive, a regulator, and a system operator. And since January, Audrey has been at Alphabet, Inc.’s research and development arm, X, where she leads the Grid Moonshot Team, which is undertaking an effort to build new tools for visualizing, planning, building, and operating our nation’s electrical grid using clean energy. That’s the kind of private sector engagement and leadership our climate challenge demands. We’re thrilled, Audrey, that you’re joining us here today to offer thoughts on what our Storage Shot would mean for you, for your team, and the potential it offers to the private sector. Please welcome Audrey Zibelman.

AUDREY: Thanks, and thank you, David. It’s a pleasure to be here. I really appreciate the Department of Energy’s leadership with respect to storage, and particularly long-duration storage. I think something, David, you worked on when you were at the International Energy Agency was a report that detailed what happens to power systems as we see higher penetration of renewables of all types, both on the grid and on buildings, et cetera. And what becomes really clear, and my experience in running the power system in Australia certainly brought this home to me, is that once you get past 20 to 30 percent penetration of renewables, the whole system changes. It becomes faster. It becomes much more granular in terms of the information you require. It becomes certainly much more complex, because what’s happening is in local places you have much more correlation of resources, and you need to integrate a greater portfolio of components. But all that gets down to is that you need a huge amount of flexibility in the system. You need to be able to respond instantaneously in changes, and you need to recognize that as weather becomes some of your biggest fuels, storage becomes an increasingly critical feature in managing the grid so that it can take advantage of the free fuel of weather and become much more efficient as well as resilient, as well as reliable. And so, you know, as we think about decarbonization and we know that the future of economic decarbonization depends on the decarbonization of the power system, it’s equally clear that the decarbonization of the power system is going to be dependent upon our ability to produce cost‑effective and all sorts of variety of storage, from long-duration storage that we can use when we know that we’re going to need it for days or weeks, to short duration storage that can respond very quickly. The other piece that I think is equally clear is that with the ability to make storage economic, we can also achieve our goal of not only making the grid more efficient, more resilient, more reliable, and affordable, it’s also more equitable. We can create things like community energy that we use in New York and California and other parts of the world so that it’s not just being able to put storage in your home but actually storage in the community, and it creates that level of engagement that’s necessary. And lastly, the other thing that I think is really going to be important and a key element to all of this is the leadership and the strong leadership that the Department of Energy and the administration is providing. As Ali noted, in New York we learned a lesson, and it’s been learned over and over again that policy leadership is key because it allows us to get to scale, and with scale we can have deployments, and with deployments we can reduce cost. So, I very much appreciate the time and the effort that the DOE is putting into this. I think having a moonshot for storage is going to be really critical, and I look forward to continuing to work with the department and our partners at X, who are helping us develop these tools that are going to enable this future. Thank you.

DAVID: Thanks very much, Audrey. I have to comment that any organization that you work on that just has a single letter is a pretty cool organization or effort. So, congratulations on that. That must look great on the CV just to have the letter X. Just a quick follow-up question, Audrey, for you, just taking advantage of your vast experience in a number of not only just different roles but also in a couple different continents. How do we do everything, right? Like we need to have the grids not only integrating more and more renewables, but we have to have the reliability, the affordability, the resilience from climate resilience, from cybersecurity. How do we maintain the best attributes, what we rely on for the grids today, but do that in a way that allows us to achieve our clean energy targets? Any additional thoughts that you want to bring about how to—and again, doing that in the real world? We’re not just doing this as an academic exercise, right; we’re trying to actually do this so that everybody has those attributes on their grids where they live.

AUDREY: Sure. You know, and it’s really—thanks, David, for the question. It’s really the heart of what we’re trying to do at X. So, look, I think what we’ve learned in the last couple decades is technology’s not going to be the challenge; it’s how to drive innovation and how to drive deployment. And what we’ve seen is, of course, you know, reduction in costs of solar and wind and things like that in places like Australia, where people are putting solar on their roof in the same way they have cars in their garage. It’s no longer a vanity issue; it’s just people are just saying of course, why not. And I think that rapid change can be helped by having better information and to recognize it will be complex. So, the first piece for us—and this is what I recognized, saw, when I was running the grid—is we need better tools to provide the better modeling and transparency and the ability to actualize and essentially virtualize the grid so we can drive innovation. If people have more transparent information on the need, and this is something we did in New York, you’re going to get a much better solution faster, and to recognize that with that, we can also think about the fact that we’ve never designed or run power systems that are dependent on clean tech. By being able to apply artificial intelligence, machine learning, and advanced computing, we can provide grid operators, governments, developers the tools and information they need to be able to understand what the power system will need as we retire the fossil resources and then design for the future in a way that’s much more efficient, because what we want to do is optimize every asset, and if we can use storage in homes or communities as well as on the grid and create a full-grid optimization, what we’ll be able to demonstrate is that we will be able to make the system more efficient, more productive, and really engage at a level that makes sure that as we decarbonize other parts of the economy, we do it in a way where we’re making the capital that’s deployed as productive as possible. So, the modeling tools and what we’ve learned, you know, where we apply them is that we can drive efficiency. And so, the future is actually, can we achieve it all? We can make the power system more reliable and affordable and resilient and cleaner. It’s no more, should we debate is this an either/or proposition?

DAVID: Well, absolutely, and we live in a world where either/or is not going to cut it. We need to do both. And thank you, Audrey, for your leadership, and certainly from us at the Department of Energy for the partnership as well. So, thank you for joining us today.

AUDREY: Thank you.

DAVID: Let’s move on to our next speaker, and we’re joined by one of the Department of Energy’s biggest champions in the House of Representatives and, in fact, an alum of the Department of Energy. Before he was elected to the House of Representatives, Congressman Bill Foster worked as a high-energy physicist and particle accelerator designer at Fermi National Accelerator Laboratory. Now in Congress, he’s a dedicated and tireless advocate for evidence‑based policy in federal funding for scientific research. He serves on the House Science Committee, and Congressman Foster has fought for years for forward-thinking approaches to solving climate change and advancing energy innovation, including and especially on energy storage. And as I mentioned earlier, he was one of the key architects and movers on the BEST Act’s passage. So, when it comes to this Storage Shot, Congressman Foster gets it and is one of I think it’s fair to say, one of the fathers, godfathers, grandfathers of the Storage Shot. So, thank you, Congressman Foster, for all your incredible leadership. Over to you.

BILL: Thanks, Dave. Thank you for that introduction. And as he mentioned, I’m Congressman Bill Foster. I’m a scientist and a businessman, and I represent the 11th Congressional District of Illinois in the U.S. House of Representatives. I sometimes introduce myself as saying I represent 100 percent of the strategic reserve of PhD physicists in the U.S. Congress since I worked at the Department of Energy’s Fermi National Accelerator Lab for over 20 years. So, thank you for inviting me to be here with you today. Understanding the performance and economics of long-term energy storage will be crucial to the future planning of the grid. It is a hard truth that anytime that you add fluctuating energy sources like renewables or fluctuating demand like air conditioning to the grid, it means that you must invest in spare capacity, and that capacity remains idle much of the time. And, of course, every competing technology seems to expect that someone else is going to pay the capital cost for that idle spare capacity. And if you intend to use the free market to optimally allocate that spare capacity, then you end up with some pretty extreme price swings and some pretty extreme technical demands on components. For example, as you add more and more renewables to the grid and then you try to compensate with battery storage, what you find is that the first batteries that you buy are solving the day/night problem, charging and discharging each day to match supply and demand. And so, you recover the capital cost of those batteries fairly quickly. But if you add more fluctuating sources to the grid and/or approach 100 percent renewables, then the last batteries that you buy are solving the summer/winter problem. And so, these batteries are only charged and discharged once per year, and it takes a very long time to recover the capital costs of those batteries, and perhaps you never do. And, of course, you need a battery that will hold the charge for half a year, which certainly doesn’t appear to be the case for the batteries in my iPhone. Now, the competition for long‑term energy storage is going to be demand management and to some extent long-distance power transmission like HVDC grid overlay concepts and the like. Both of these suffer the same challenges with having to pay capital costs on expensive assets which are only intermittently used. For example, if you plan to use surplus power from renewables to make steel, then you have to figure out who is going to pay for the steel mill that will be idle for some of the time. And/or if you plan to wheel electrical power long distances so that you can geographically average power supply and demand, then you have to face the fact that much of the time that that grid overlay will not be being heavily used because the grid is in decent balance, and the economics of demand management will be important. And the economics of demand management are very different than of long-term energy storage. You know, for example, at Fermi National Accelerator Lab where I worked for 20 years, the maximum site power consumption was about 50 megawatts and depended a lot on which experiments we were running. So, we often arranged, for example, to do scheduled maintenance during times of high electrical power consumption, and from time to time we would get a call from the operators at the power company saying, you know, it’s a really hot summer evening, everyone has their air conditioning on, could we please switch over to a less power-intensive set of experiments, which we could do at fairly low cost, and we did. So, demand management will be a significant competitor to energy storage, particularly for longer and for seasonal durations. And to understand the crossover between all these different methods and the optimal allocation and all the tradeoffs, it’s necessary to have much better knowledge about the ultimate cost of long-duration energy storage. And this is why in the last Congress I introduced, along with my colleagues in the Senate, and my colleague Congressman Sean Casten, the Better Energy Storage, or BEST Act. The legislation directs the Secretary of Energy to establish aggressive goals to develop and improve capacity, targeting ultimately lower costs for grid scale storage. I’m proud that the BEST Act actually became law in 2020. It was a step in the right direction, and the Energy Storage Shot is a further bold step in the same direction. We ultimately need to do more, and as Audrey just mentioned, use all of the tools we have available to us scientifically and legislatively. You know, for example, advanced grid modeling, the advanced grid modeling program at Argonne National Lab, helps analyze the electrical power system using big data, advanced mathematical theory, and artificial intelligence and high‑performance computing to assess the current state of the grid and to understand future needs. So, thank you all for inviting me to be here with you today. You’re doing something really important.

DAVID: Well, thank you very much, Congressman, for being with us today and all your incredible leadership as an entrepreneur, as a scientist and researcher, and now as a policymaker. If I could ask you just one quick follow-up question, and we don’t have a ton of time and I want to make sure we try to stay on schedule, but if you can think about yourself as you were beginning your career, so, and based on everything that you’ve learned, again with those wealth of experiences that you’ve had, what would you say to your younger self or if you want to imagine the young researcher who’s working at, whether it’s Fermi Lab or NREL or any number of our national labs who will be working on this Energy Storage Earthshot, what lessons learned, what judgment would you tell those younger colleagues—as Ali Zaidi called them, the horde of young folks—young talent out there that we need to unleash on these audacious key technologies that we need? Any lessons learned from your perspective?

BILL: Well, I think I would tell young Bill Foster to question the stovepipe and to break out of the stovepipe, especially regarding laboratory-developed technologies that can have a real important benefit for society. You know, for example, at Fermi Lab we had a lot of interest, and I put a lot of effort into making low-cost giant particle accelerators. And so back in the 1990s, we developed extensive plans for low-cost robotic tunneling, which are in retrospect pretty much identical to what Elon Musk’s Boring Company is talking about today. You know, we use battery-powered automated service vehicles, high‑speed tunneling that eliminated most of the underground labor costs. And low-cost robotic tunneling would obviously be transformative for the underground grid infrastructure and making it more resilient, but these were not pursued at the time because, you know, the main mission of our laboratory was winning a Nobel Prize with the next very specific set of accelerators to look for very specific subatomic particles. And, you know, similarly, back in the 1980s, there was a really interesting set of papers that came out of Lawrence Livermore Lab and Lawrence Berkeley Lab proposing to use particle accelerators called induction linacs for hard‑rock tunneling. They made the key measurements and worked out machine parameters that indicated that you could achieve tunneling rates of up to 10 meters per hour in hard rock, but this was also not pursued because, you know, how many Nobel Prizes is it going to get this month, and so I think that researchers should always keep their eyes open. Even though they’re focused on some really interesting scientific question, if they see an application to society, don’t be shy about spending part of your career pursuing that and making sure your laboratory management is equally dedicated to making the world a better place.

DAVID: Well, what terrific advice, Congressman. Avoid the blinders, question the stovepipes, and look for opportunities across different disciplines, different sectors. Well, thank you, Congressman, thank you for all your leadership and your support and partnership with the Department of Energy and the Storage Shot in particular.

BILL: Happy to do it.

DAVID: Great. All right. We’ve got one more keynote speaker. We’ll hear from another colleague of Congressman Foster and Senator Collins on the BEST Act. In fact, another senator from Maine, Senator Angus King. Through his work on the Committee on Energy and Natural Resources, Senator King has had an influential leadership role in shaping energy policy in our country for many years. I recall my confirmation discussion with Senator King, where we spent at least half of it talking about storage and the importance of storage. So, again, another father of this Storage Shot and just a terrific advocate for innovation in clean energy technologies. A strong ally for the department, big believer in our Storage Shot. Please welcome Senator Angus King.

ANGUS: I think energy storage is the real Green New Deal. I think energy storage is what is going to change the face of energy production and consumption in this country. Renewables are poised to go. Solar and wind are there, they’re being deployed at a very large scale. The missing piece is backup. The missing piece is storage. Now, right now the backup is being provided mostly by natural gas, but energy storage that’s cost-effective—and I know the Storage Shot that you’re talking about today, we’re talking about driving that cost down by 90 percent. That can be done. It happened with solar, starting back around 2005, 2006. So, we know that that can be done. It’s a question of bringing it to scale. It’s a question of new research, new technologies, new breakthroughs. So, I want to commend the secretary, Secretary Granholm, for conceiving and developing this idea of a Storage Shot, of an Earthshot involving storage because as I said, I think it’s the key, it’s the absolute key to a carbon-reduced future. If we can have the backup power that isn’t fossil fuel-based, we can go to an entirely renewable energy electricity system. Then we can move toward the electrification, we are moving toward the electrification of transportation, and when you do those two things together, that’s two-thirds of the carbon going into the atmosphere. And then, of course, their work in things like heat pumps that deal with space heat, that’s the other third, and we’re getting there. So, storage is the key, and that’s why I think this Earthshot, this Storage Shot, is so important. Research is the name of the game. We’ve got to develop new technologies, technologies that perhaps don’t use some of the rare earths and some of the mineral materials that we have to import. Let’s look for solutions that can be homegrown. So, thank you for the work that you’re doing. I cannot, I cannot convey more strongly how important it is. I think this is the key to a clean energy future. Congratulations for setting this goal, good luck in getting there, and thanks for the work that you’re doing on behalf of our country and frankly, for the planet.

DAVID: Well, thank you very much, Senator, and thank you for your incredible, outstanding leadership on clean energy technologies, including and especially on storage. Now we’ve heard the perspective of a variety of policymakers, innovators. We’re going to turn to power operators themselves, to a panel discussion about power operators, what hitting this energy storage target would mean for our grid systems, for customers. Joining us now on our End User Panel are Gia Mahmoud of National Grid, Clay Koplin of the Cordova Electric Cooperative in Alaska, and Chris Ayers from the North Carolina Utility Commission. And I’m going to turn it back to my colleague, Pat Hoffman, to moderate this panel. Pat, over to you.

PAT: Thank you, Deputy Secretary Turk, and our morning panelist of speakers, for your insights today. In this panel, we would like to briefly discuss two areas and two use cases: grid-scale applications of long-duration energy storage and remote communities that are frequently disconnected or may not have access to the grid. As we advance long-duration energy storage, it will be important to highlight structural issues and other constraints that may affect these applications differently so we can incorporate that into our roadmap and strategy. So, from this panel I hope to hear how different geographies, applications, and end users will affect our long-duration energy storage strategy. I am very pleased to introduce our panelists, who were gracious enough to join us from all over the country and share their experiences. This will be something of a lightning round. So, I ask our panelists to keep their response to approximately two minutes apiece. First, I would like to introduce Gia Mahmoud, the head future of electric from National Grid, which serves customers across New York, Massachusetts, and Rhode Island. Gia, how would you achieve the Long Duration Storage Shot target, and how would this benefit or affect your system, considering the electricity demand profile you support and the renewable energy mandates that you must achieve in the coming decade?

GIA: Thank you. Thank you, Patricia. Thank you for the introduction and thank you for having me here today. It’s really a pleasure to be participating in such an important dialogue. It’s really a great time to be in the energy business. And together, we have an opportunity to deliver this clean energy future. At National Grid, that is our priority across our U.S. footprint. We are investing in our energy infrastructure to improve the reliability and resiliency as well as to modernize our grid to accommodate more customer-owned generation. Like everyone else, we are continuing to drive innovation to creative clean energy solutions that address our customer needs to non-wire alternatives like energy storage to really mitigate the need for traditional infrastructure investments and upgrades that will otherwise be required. So, long-duration storage is a very important tool in our toolbox. As we start to integrate more and more solar and wind to our system, we are looking for solutions to be able to store power for distribution at times when the wind is not blowing or the sun is not shining. So, low-cost, long-duration storage will help create major, major customer benefits for us and will affect our system in various different ways. As I think about it, load due to electrification, when we see our system due to heat electrification moving from a summer peaking to a winter-peaking system, some areas will experience significant load prod. And the short duration heat production are shading. It is no longer going to be sufficient to meet the customer demand. We need solutions like long-duration storage to need to replace the capacity. To date, what we have seen that the short-duration storage like lithium is cost-effective for peak sharing, but when our assets are loaded for more hours than just peak, storage is really not economical anymore. From my experience, most of our non-wire alternatives largely fail because of the cost benefit analysis when they’re hitting a need for even four to five hours of load relief. So, programs like this, you know, DOE Long Duration Storage Shot and other companies like home energy looking to really reduce down the storage cost targeting like 90 percent reduction of the cost, but some numbers as I just saw floating around five kilowatt per hour is the cost level that we really need if you need to defer the capacity in some areas. Also, thinking about the seasonal storage, it will be very beneficial. With the major transition to electrification of heat, we may require shifting renewables from the summer to address winter peaks. Another area is the distributed generation enablement. Similar issues as load prod for some minor solar and wind production. Short storage can absorb that, but with the heavy penetration of solar and wind that we are expecting to see in the 2030 and 2050 timeframe, short-duration storage is not going to be economical anymore, especially looking at today’s cost point. So, we really need this low-cost, long-duration storage solution. And my last point is about the outage duration and for resiliency in the climate change mitigation. This long-duration storage will help make microgrids, as you just mentioned, in remote areas will be as backup power solutions, really make it more reliable and effective. We are actually trying the solution in our Upstate area in all forge where we have some reliability concerns, and we are trying to see if we can create a small microgrid using energy storage. And the sizing of the old forge can only handle four hours of the peak load, and that was mainly designed to be able to make sure its cost and benefit is there. So, if the cost of storage was lower, we could have greatly increased the size of these applications and allowed to ride through for hours, if not days, of an outage. So, really improving the reliability and resiliency, also thinking about the areas, you know, which are vulnerable to the climate change like our environmental justice committees. How can we help them? How can we bring them along? So, the increased adoption of renewable energy, this dynamic change in the customer demand, as well as the stresses from the weather are really highlighting the need for this enhanced solution like long-term storage, which, if cost-effective, can really ensure the continued reliability and resiliency of the grid and can help us meet the affordable clean energy future. So, thank you.

PAT: Gia, thank you so very much for your comments. Very important to hear from you with respect to how the demand profiles, the low-duration curves are changing, and how you’re looking at being aggressive and addressing the needs of the future for your communities and your customers. So, I appreciate that very much. Our next speaker is Clay Koplin. Clay, it is so nice to see you again. Clay is the CEO of Cordova Electric Cooperative in Alaska, which serves remote communities in Alaska. Clay, how would achieving the Long Duration Storage Shot affect your system and your customers?

CLAY: You know, Cordova is such a small, isolated microgrid community here in the Gulf of Alaska. We just have 2,300 residents. We’re not connected to other grids. Very difficult for us to have economies of scale. So, we’ve had a lot of assistance from the Department of Energy over the years to develop run-of-the-river hydro projects. We’ve been fortunate to be able to get to 80 percent renewables and reduce our cost of energy, and frankly, that low‑cost energy for the citizens and those in the community that struggle the most to pay it has really been a gamechanger for our industry of processing wild Alaskan seafood and our famous Copper River salmon. We’ve become the 11th-largest seafood port in the United States just as a small community. Most recently, we were able to add some energy storage in working with Dr. Emery Juke [ph.] of the Office of Electricity, who helped us with the technical aspects to make sure we had the right size and technology for our system. We were able to save 65,000 gallons of diesel fuel last year. So, that’s one big step closer to being to our ultimate goal, which is being completely off of fossil fuels. Once we close that gap, and it’s going to take energy storage to get there, then we can look at even further benefiting our community by electrifying our transportation, our cars, maybe someday our fishing fleets, and electrifying the heating of our home with new technologies like air-source heating. So, it really is the holy grail for us to have long-duration storage, and we’re looking forward to opportunities. Dan Tawn [ph.] in the Office of Electricity and Alejandro Moreno in the Energy Efficiency and Renewable Energy Office have helped us through the RADIANCE project here in Cordova to modernize our grid and be very efficient with the resources we have, but they just can’t replace the need for storage. Once we can get some long-duration storage and save that extra power we have in the summer and add some solar, we can be completely renewable. So, it's a very exciting program, and we’re very fortunate that the department has this focus and can help us make this transition.

PAT: Clay, thank you very much for your comments and the insights you provide as well as the documented benefits of some of the significant climate as well as other achievements for your community. So, I really appreciate your comments and your insight today. And last, but not least, I would like to introduce our final panelist, Chris Ayers. He is the executive director of the North Carolina Utilities Commission and a very important perspective that we would like to hear from today. So, Chris, from the consumer advocates perspective, how are you seeing, or do you foresee long-duration energy storage impacting or benefiting your constituents? What considerations or information do you feel is needed from your perspective to facilitate long-duration storage projects and getting approvals from whether it’s commissions or other regulatory entities?

CHRISTOPHER: I think it’s absolutely critical, and I’m excited that DOE is investing in the effort to make long-duration storage more cost-effective. I mean, at the end of the day, consumers are ultimately going to bear the cost of the energy transition, and anything that we do energy-wise, customers ultimately pay that price. So, as a consumer advocate, it is in our interest, in the interest of customers to make sure that that transition is as orderly and as cost-effective as it can possibly be. And long-duration storage, I think, fills in the gap that we’ve been looking at for some time. Long-duration storage is going to allow for more cost-effective planning, more holistic planning, and better integration of distributed energy resources. So, here in North Carolina, we have an abundance of solar energy right now. Over the last 10 years, we’ve seen an explosion. We’re fourth in the country in terms of installed solar, and that runs when the sun’s out, obviously. But you may not realize this, that North Carolina over the last 10 years has actually moved from summer peaking to winter peaking. And so, we need that energy that is produced in the afternoon in large quantities, we need that at six and seven, eight in the morning on January, February, March mornings, and right now, we don’t have the technology that allows us to bridge that gap. Once we have long-duration storage, start integrating that into the system, we can become more cost effective by also leveraging low-cost energy generation. We have a good deal of nuclear in North Carolina, and that runs constantly, but a lot of times there is an abundance of nuclear on the system, say in the evenings particularly in your shorter seasons. So, the ability to capture this energy rather than paying someone to take it or selling it somewhere at less-than-optimal prices, that’s going to make the entire system more cost-effective for customers, and that’s a win for everyone. In terms of the remote—when you asked about remote nature of communities, you know, North Carolina, we have our fair share of hurricanes. And so, resilience is something that immediately comes to mind when I’m thinking about other ways that consumers can benefit. Storms, winter storms, summer storms, we have mountainous areas, we’ve got barrier islands. The ability to deploy long-duration storage can really help us bounce back from those natural events that are becoming more and more frequent and ensure that customers are not left in the dark or left in the hot or the cold when we experience those events. So, I’m excited about the prospect of long‑term storage. I think it bridges a number of gaps, and ultimately customers, you know, it’s a derivative impact to some extent, but it’s going to make for a more cost-effective system that customers will ultimately be paying for.

PAT: Thank you so very much, Chris. I really appreciate your comments as well. Thank you once again. So, I would love to continue the dialogue with these esteemed panelists because there is so much more to talk about in this time space, but I recognize that we are short on time. So, with that, I would just once again like to express my special thank you. Gia, Chris, Clay, I really appreciate your comments today. We look forward to having continued dialogue with you as we continue to develop our roadmap. We hope that the dialogue here has opened a lot of thoughts for folks that are participating in this summit, but as mentioned, energy storage is critical as we want to engineer it in our system. And whether markets can truly capture all the benefits or not, we need to invest aggressively in energy storage, whether it’s as a transmission asset or in communities or with consumers directly. So, once again, thank you, everybody, for participating, and I appreciate the panelists for their comments today. Now I would like to turn the mic back over to Deputy Secretary Turk for closing comments.

DAVID: Well, thank you very much, Pat, and thank you to all of our excellent panelists and speakers in this session today. I took three common threads, either explicit or implicit from every one of our panelists and speakers today. First, what we’re doing with this Energy Storage Shot is incredibly, incredibly important. This isn’t a sideshow; this is one of those key technologies that we need to focus on and reduce those costs. Secondly, this isn’t going to be easy. Ninety percent cost reductions with a key technology area like storage is not going to be an easy thing to do. If it were easy, it would already be done, and it wouldn’t be something that we’d need to focus an Earthshot on. So, there’s a lot of work that we need to all undertake together. And then three, and I think most importantly, what I heard from all of our panelists is this can be done; we can do this. This is in our control to step up to the plate and get it done. And not only can we do it; we must do it. So, let me conclude this session by thanking everyone in advance for succeeding on this Storage Earthshot. From the Department of Energy, the Office of Electricity that Pat leads, our Renewables and Efficiency Office, our Office of Science, ARPA-E colleagues, all of our National Lab colleagues, of course working with all of our partners, utilities, state policymakers, entrepreneurs, companies, investors, we all need to step up, roll up our sleeves, and get this done. There’s no other alternative here. So, thank you in advance for being successful on this Storage Shot. And with that, Meredith, let me turn it over to you to highlight and preview some of the afternoon sessions today.

MEREDITH: Thank you so much. Thank you to everybody. This was a fantastic way for us to kick off the day. A lot of information from all of our speakers, and we really, really appreciate it. This afternoon, we are going to hear about how DOE is mobilizing to achieve the Long Duration Storage Shot goal. Right now, we’re going to let everybody take a quick break. So, grab some breakfast or lunch, depending on what time zone you’re in; check your email. Meet us back here at 12:15 eastern or 9:15 a.m., for those of you who are on the west coast. Keep the volume up on your computer, and when you hear my voice again, you’ll know that we are going to be starting the next session. So, we will talk to you soon. Thank you all very much.

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