

Accelerating Clean Energy Innovation in the United States

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Webinar Panelists

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Speaker

Sean Esterly Hello, everyone. I'm Sean Esterly with the National Renewable Energy Laboratory. And, welcome to today's webinar, which is hosted by the Clean Energy Solutions Center, in partnership with the United States Department of Energy. And today's webinar is focused on accelerating clean energy innovation in the US. And one important note of mention before we begin our presentations is that the Clean Energy Solutions Center does not endorse or recommend specific products or services. Information provided in this webinar is featured in the Solutions Center's resource library as one of many best practices resources reviewed and selected by technical experts.

And just want to go over some of the webinar features for the audience. For audio, you do have two options. You may listen on your computer, or through your telephone. If you choose to listen through your computer, please select the mike and speakers option in the audio pane to help eliminate feedback and echo. And if you choose to dial in by phone, just select the telephone option box on the right side, will display the telephone number and audio PIN you can use to dial in. If anyone's having technical difficulties with the webinar, you may contact the GoToWebinar's help desk at the number displayed at the bottom of the slide. And the number is (888) 259-3826. They can help you out there.

And at any point during the webinar, if you have questions for our panelists today, we do encourage you to submit those through the questions pane, and we will then present them during the question and answer session, following the presentation. If anyone's having difficulty viewing the material for the webinar portal, we will be posting PDF copies of the presentations at the

Clean Energy Solutions site, their training page. And you may download those later, along with an audio recording of today's webinar. And, just a reminder, we're also posting the recordings to the [Solutions Center YouTube](#) channel, where you can find other informative webinars.

And today's webinar agenda is centered around the presentations from our guest panelists—Dave Turk, Joseph Hezir, Dr. Lynn Orr, and Dr. Sanjiv Malhotra—all from the US Department of Energy. These panelists have been kind enough to join us today to discuss key policies and programs aimed at accelerating clean energy innovation in the United States, including innovative models of government industry collaboration and transitioning new technologies from the laboratory to the marketplace.

Before our speakers begin their presentations, I'll just provide a quick informative overview of the Clean Energy Solutions Center Initiative. Then, following the presentations, we'll have the question and answer session, where panelists will address questions submitted by the audience. Followed by some closing remarks and a very brief survey for today's attendees.

So this slide provides a bit of background in terms of how the Solutions Center came to be formed. Solutions Center is one of 13 initiatives of the Clean Energy Ministerial that was launched in April 2011, and is primarily led by Australia, the United States, and other CEM partners. The outcomes of this unique initiative include support of developing countries and emerging economies through enhancement of resources on policies relating to energy access, no cost expert policy assistance, and peer to peer learning and training tools such as the webinar that you're now attending.

And there are four primary goals for the Solutions Center. First goal is to serve as a clearinghouse of clean energy policy resources. Second is to share policy best practices, data, and analysis tools specific to clean energy policies and programs. And the third goal is to deliver dynamic services that enable expert assistance, learning, and peer to peer sharing of experiences. And then the final fourth goal is to foster dialogue on emerging policy issues in innovation from around the globe.

And our primary audience is energy policymakers and analysts from governments and technical organizations in all countries. But then we also do strive to engage with the private sector, NGOs, and civil society as well.

And so this slide provides an overview of one of our marquee features that the Solutions Center provides, which is the no cost expert policy assistance, known as Ask an Expert. And the Ask an Expert program has established a broad team of about 40 to 50 experts from around the globe, who are each available to provide remote policy advice and analysis to all countries at no cost to you. So for example in the area of green growth strategies, we're very pleased to have Thomas Heller, executive director of the Climate Policy Initiative, serving as one of our experts.

So if you have a need for policy assistance in green growth strategies, or any other clean energy sector, we do encourage you to use this valuable service.

And, again, the assistance is provided to you free of charge. If you have a question for our experts, please submit it through our simple online form at cleanenergysolutions.org/expert. And we also invite you to spread the word about this service to those in your networks and organizations who may be interested.

And so I'd like to provide some brief introductions now for today's panelists. First speaker up today is Dave Turk, deputy assistant secretary for international climate and technology, at the Department of Energy. And in this role, Dave helps to coordinate the department's international climate change and clean energy efforts.

Our second speaker following Mr. Turk will be Joseph Hezir, the Department of Energy's chief financial officer. And, as CFO, Mr. Hezir seeks to assure the effective management and financial integrity of the Department of Energy, and help implement and monitor department-wide policies and systems in the area of budget administration, program analysis and evaluation, financing and accounting, internal controls, corporate financial systems, and strategic planning.

And, after Mr. Hezir, we will hear from Dr. Lynn Orr. Dr. Orr is the undersecretary for science and energy. And as undersecretary, Dr. Orr is the principal advisor for the secretary and deputy secretary on clean energy technologies, and science, and energy research initiatives.

And our final speaker today will be Dr. Sanjiv Malhotra. Dr. Malhotra serves as the director of the Clean Energy Investment Center, located within the office of technology transitions, where he focuses on advancing private mission-oriented investment in clean energy technologies that address the present gap in US clean tech investment.

And so with those introductions, I'd like to now turn things over to Dave Turk for his presentation.

David Turk

Thank you, Sean. And thank you for everyone joining the webinar today. This will be the first in a series of webinars on Mission Innovation. Before turning it over to my colleagues to focus on the United States for this particular webinar, I'll provide a little bit of context for Mission Innovation as a whole, as the global effort that it is. And today's webinar is focused on the United States, but will have subsequent webinars with respect to other countries and what they're doing under Mission Innovation. We'll have India, and France, and Canada, UK, Sweden, and Mexico, just as a preview of coming attractions.

So let me just start with the start of Mission Innovation itself, at least as a global effort. You see a picture here on your screen from the last November 30, the first day of the Paris COP. You see a very high-level cast of characters, leaders in most instances, from the 20 original countries of Mission Innovation. You see President Obama, President _____, Prime Minister Modi, and then others there as well. It was 20 countries who all came together to focus on clean energy innovation as a key part of the climate

solution, but also as a key part of other efforts as well—economic development, economic productivity, energy security, etcetera.

The key part of Mission Innovation, as you see in the first bullet, is each of these countries at a high political level, at the highest political level, made a commitment to seek to double their clean energy research and development budgets over a five-year period of time. Each country is also going to look for different collaborative opportunities with private sector, with investors, with also other Mission Innovation countries also.

You also see one non-world leader in this picture, and that's Bill Gates. As Mission Innovation was being launched, a private sector initiative by Bill Gates and 27 other investors, something called the Breakthrough Energy Coalition, was also launched, on that same date.

So what's the rationale behind Mission Innovation? Why did these 20 countries come together to double their clean energy research and development budgets to double down on clean energy innovation? Certainly, there's a climate change imperative here, as you see on the left of your screen. I don't need to go through the science. But GHG atmospheric concentrations are increasing. We're seeing the impacts already. Scientists are warning us of additional impacts going forward.

We see the business-as-usual approach is unacceptable and going to lead to even worse consequences going forward. We also of course had terrific success at the Paris COP where countries around the world put forward their own nationally determined contributions. The one thing that's been readily apparent by everyone analyzing those contributions, while a very good first step, if you will, they don't get us all the way to the level of ambitions scientists tell us we need to, to avoid the worst consequences of climate change.

And one part of the solution is to develop those new technologies to keep pushing the costs of technologies down, so they can be more widely used in markets. So you see a slide to your right showing some of the power of innovation and what it's led to over just a relatively few years with certain technologies. You see at the left side of your screen, everything starting at the 100 percent index cost. Then you see the cost reductions that have been achieved—LEDs being the most dramatic that you see in light blue at the very bottom, going to under 20 percent, 10 percent cost.

But you see some of these other cost reductions that have been achieved. The whole theory of the case, if you will, on Mission Innovation, from the climate side, is to keep developing those new technologies, to keep driving down those costs, and to do so as quickly and focus on transformational areas as well. Obviously, climate benefits, but economic benefits, energy security benefits, as well, on that front.

So Mission Innovation countries literally span the world. As you see on the screen in front of you, all the countries in blue are Mission Innovation countries. We include the five most populous countries, 60 percent of the

world's population. You see some of the other statistics up there. Probably the one most relevant is the last one there, where it says well over 80 percent of government investment in clean energy R&D are encompassed in 20 countries who have joined Mission Innovation, and our newest partner, the European Union, as well.

We had an inaugural Mission Innovation ministerial in which all our ministers for Mission Innovation countries came together a few weeks ago in San Francisco, and there were a few outputs from that, a few deliverables, or announcements, from that. I think the most significant was going from a general commitment to double over five years, to each country specifying what its particular baseline is, and what its double plan is. So to provide some meat on the bones of these particular commitments. This chart you see in front of you summarizes the level of investment that these 21 governments are bringing to the table on the government side.

So if you add up everyone's baseline, you get to a \$15 billion per year total. At that 2016 timeline. And you see with that doubling commitment—that takes us to a \$30 billion per year goal to be sought in five years by 2021.

There were a number of other announcements and deliverables at the ministerial itself. We added our 21st member, the European Union, joined Mission Innovation. We made some organizational decisions. We adopted an enabling framework. There was some analysis and a report done on technology roadmaps. And we had some back and forth with some key business leaders, including Bill Gates and some members of the Breakthrough Energy Coalition as well.

Variety of different documents that might be of interest to a variety of folks on the phone can be found at our website. It's www.mission-innovation.net. Including a summary of each country's doubling plan, a compilation of those doubling plans, along with some of the other analysis that has already taken place. You'll also see there we've got a summary video of the panels, both the public panel and private panel at the event. And a video from the ministerial itself. Then just to end where I started this is the first of a webinar series. We'll have a number of other countries presenting on their particular doubling plans, and their particular efforts under Mission Innovation. But without further ado, let me turn it over to Joe Hezir, who's going to start our presentation on the United States, and its efforts under Mission Innovation. Joe?

Joseph Hezir

Okay. Thank you. Thank you, Dave. Let me start off then by providing a little bit of budgetary context. And then from there we'll kind of drill more deeply into the program content. David mentioned that among the 20 countries at the San Francisco conference, they established a baseline of about \$15 billion. For the US, our contribution to that baseline is \$6.4 billion, or roughly about 40 percent. We're probably the largest single country in that regard. And within the US, we have within the federal government about a dozen agencies who have some role or other in Mission Innovation. But of all of them, Department of Energy is by far the largest.

And we've established for ourselves a baseline of \$4.8 billion, roughly three-quarters of the total US. We've also under the—each country has flexibility in terms of how they define the scope of their clean energy R&D portfolio. For the US, we're focusing more on the early stage research and development activities. But we're including all research and development and demonstration activities, but for purposes of Mission Innovation, we're not including our various deployment programs.

So we're focusing more on the innovation side of things. And also in terms of our baseline portfolio, we've taken a very broad definition of clean energy technology. Looking at all technologies, all stages of the energy cycle, and any technology that has the characteristic of contributing to a reduction in net greenhouse gas emissions. We also not only want to simply focus on greenhouse gas emissions, but also look at technologies that have other environmental benefits as well.

So this chart here gives you an overview of our budget. And as I said, we started out, if you look on the down toward the lower left hand bottom of the chart, our Mission Innovation base was roughly \$4.8 billion. And actually, within the Department of Energy, our total energy and science portfolio is actually \$9.5 billion. So we're roughly about half of that we are considering to be Mission Innovation. And excluded from that are things like the deployment programs, and at the very back end of the innovation cycle, and we've also excluded for Mission Innovation our discovery science programs at the very end of the scientific cycle. Things like particle physics and programs of that nature.

In our FY17 President's Budget that we sent to Congress back in February, we set out a very ambitious path towards our doubling path, with respect to DOE at 21 percent increase in budget that we requested from Congress in 2017. But as you can see from the table, and I'll kind of run through this quickly, is that we did not necessarily increase everything at the same rate. We really tried very hard to set priorities based upon where we saw the greatest innovation potential.

So, for example, in the energy efficiency and renewable energy area, in our Mission Innovation budget, we had almost a 50 percent increase in FY2017 budget. In ARPA-E, we had roughly a 20 percent increase. And, as we'll talk about later, we're trying to move ARPA-E from a current funding level of about close to \$300 million, eventually up to a level of about \$1 billion a year. In the science area, a slightly less of an increase. We had a fairly large base to begin with, but also a 17.5 percent increase.

Then some of our applied technology areas, lesser increases. So for example in the office of electricity, a 15 percent increase. In fossil energy, a 6 percent increase. And a slight decrease in nuclear energy. And a lot of that also reflected timing considerations. Where in our doubling path, we really wanted to emphasize some of the earlier stage research in the earlier years of the Mission Innovation portfolio, and we will bring in greater investments in the applied areas, as these early investments hopefully lead to some very beneficial results.

So I think with that as an overview, I'm going to turn it over to Undersecretary Orr, who will begin to drill down more into the programmatic content, and the various priority areas we've tried to emphasize then within our budgetary portfolio.

Franklin Orr

Thanks, Joe. It's a pleasure to be able to talk a little bit about the science and energy research that is part of our portfolio now, and the kinds of things we might do in an expanded research portfolio going forward. I'll say at the outset that we have done a fair amount of experimentation in recent years. In looking for ways to bring together researchers to work on hard problems that really do contribute across the spectrum of energy conversion technologies. Some of that work is at the fundamental end of understanding things like catalysis that play roles in very—gosh, in all kinds of chemical processes and batteries and fuel cells.

All the way to the other end of the spectrum. Where we really are looking at manufacturing and so on. So what I'll do here at the beginning is just say a few words about each of the kinds of research entities we've used, and how we think those might contribute in the future. The first of these is illustrated on this slide, the Energy Frontier Research Centers. These are entities. We select them based on rigorous proposals and a substantial peer review system. They bring together academic organizations, our national labs, and industry as well. And they're distributed around the country. We have 32 of them active now.

The next slide, for example, illustrates some of the areas in which we work. If you scan through the titles of these Energy Frontier Research Centers, you'll see catalysis appears in a number of places, because catalysts are everywhere in energy conversions. You'll see nano-structured materials. Our ability to control structures at very small scale. Gives us some ways to control what happens as you convert some primary energy resources into an energy service, like electricity, for example. And these have a focus on fundamental mechanisms, but they're ones we know would really have an impact if we understand them better and give us opportunities for applications going forward.

The next says something about how these effectively—these formats, these research formats, have been. There's been a steady increase in peer-reviewed publications. An equally steady increase in patent disclosures and patent applications in the US. There has been quite substantial interaction with companies of all sizes. I'll illustrate that a bit more in a moment. But some are large companies that really make use of the science parts of this. Midsize companies. And even startup companies.

And at the end of our presentation today, Sanjiv Malhotra will talk more about the various ways that we interact with companies. An important part of what we try to do here is make sure that the ideas that come out of the scientific enterprise find their way into various applications.

The next slide really just attempts to illustrate this idea of how the range of companies that have interacted with our Energy Frontier Research Center

activities. In the center are some pretty big companies—Intel, DuPont, GE, Dow, Ford, Toyota, and so on. And then distributed around the outside are midsize to quite small companies. We view all of these as an important part of the innovation process. And it's part of this idea of a portfolio of investments that can contribute in a way to move ideas from the laboratory into commercial application. Next slide.

We've also experimented with something we've called the Energy Innovation Hubs. These are somewhat larger projects. The EFRCs tend to be in the \$3-5 million range for funding. These Energy Innovation Hubs are bigger. They're more focused on some specific activity. For example, the first one on the slide is the Critical Materials Institute. This has to do with rare earth materials that are sprinkled throughout particularly in magnets that find their way into wind turbines and all kinds of other applications.

And understanding how those—how to separate those effectively, how to find them and recycle them, those are all ways that can contribute across the energy spectrum. We have a new one that's devoted to energy and water. Energy and water are hugely connected parts of the energy systems. And being more efficient in the way we use water and energy associated with water is an opportunity for doing better as well, and so on. You see the idea.

There's one devoted to batteries and energy storage. This is in recognition of the fact that in deep penetration of renewables like wind and solar into our electric power generation system, it's very useful to have some energy storage. And batteries and other storage mechanisms can play an important role in that. This particular center is focused on the fundamentals of new battery chemistries that might allow higher density electricity storage, along with good power delivery. And the durability and safety that are important throughout our energy systems. So the energy hubs are part of our mix as well.

We also have put some effort into an advanced manufacturing initiative. This recognizes the fact that no matter how cool that laboratory scale energy device might be, we really do have to manufacture and distribute and use these systems at large scale in order to have an impact on greenhouse gas emissions, and our energy use as a whole. So we've tried to invest here in areas that have widespread application in manufacturing, looking for efficiencies there, thinking about how to recycle materials so the life cycle use is well controlled. And really trying to find ways to make efficient use of the idea generation that can come out of the fundamental scientific work.

Just to—I mentioned the Critical Materials Hub already. We also have an institute that looks at advanced composite materials. These are often carbon fiber based systems that have high strength and low weight, so offer opportunities for efficiency in a variety of places. The Power America Manufacturing Institute is aimed at wide band gap semiconductors. So these offer the potential at least for much more efficient power conditioning and transformers and could make our whole electric power generation and distribution system more efficient. So a focus really at the other end of the process. Next slide.

Another way we've attempted to move ideas from the laboratory into commercial application is the ARPA-E project, the Advanced Research Projects Agency for Energy. This one really focuses again on early stage technologies. But with an effort to go from some laboratory concept, and typically we do have a proof of concept idea, experimentation and analysis, underway. But now it's time to try to move that into a prototype that could be the basis for going forward.

It was established in 2009. So we have a bit of a track record now. And it really has proved to be something that has been quite successful. This is an area where we would definitely intend to invest further. As we work on the Mission Innovation approach. For example, the US National Academy of Sciences recommended in a study a while back that we really move this up to the \$1 billion a year level, from its requested level this year of \$350 million a year.

If you look at the projects we funded, we've laid out about \$1.3 billion, cumulatively, through a series of solicitations. These are done with some tough targets, often in focused areas, but every once in a while, in an open solicitation, looking for good ideas. We have a couple hundred projects completed, and a number of those have been successful enough to attract an additional roughly about the same amount of money, \$1.25 billion, in private sector follow-on funding. And quite a few projects have also formed new companies. And some have found support with other government agencies and programs to develop further along the path. So we're quite enthusiastic about its impact. And it's one of the other important ways we try to really move ideas out of the lab to the marketplace. Next slide.

And finally, we've put some effort into areas where we recognize that there are crosscutting activities that apply really across the various kinds of expertise that we have within our own agency. And tried to bring together teams to work on these in an interesting way. To try to do some things that no one of our programs could do individually as well as a carefully coordinated effort would be able to deliver.

The one I'd single out for recognition is the grid modernization effort. We've recognized in the United States that we have a grid that's been in place for a long time that could use a substantial improvement. And an effort to modernize the grid would be a good thing that would really help us across the energy spectrum. We also recognize the importance of high performance computing. So we are investing in an exo-scale computing efficiency initiative. And we also recognize the value, for example, of advanced materials. Materials science plays a role in pretty much every energy transformation method. And having more tools available in the advanced materials area gives us some opportunities as well.

So just on the next slide, I'd just say a word or two about the kinds of things that we anticipate investing in. And these are the kinds of things we have requested additional funding for in the fiscal year 17 budget that's under consideration now in our Congress. I'll let people read these on your own, but they range from investments in research, nuclear reactors, to offshore wind, to

investments in our biological energy research centers, to our national laboratory user facilities, that form an important component of all kinds of research in materials science and biochemistry around the nation.

Again, computing. Efficient trucks. That's the Super Truck Two effort. Carbon capture and storage. Looking at ways to reduce the cost of capturing CO₂, for geologic storage. And those kinds of things. We are engaged in a planning exercise now that is one that we will use to understand potential pathways going forward in the next five years. To do that, we'll make use of some recent studies that we've done, the Quadrennial Energy Review, and the Quadrennial Technology Review, in a slide coming up in a bit, too, you'll see links, if you'd like to have your very own PDF copies of those. They're available for anybody to look at and use.

So with that, I think I'll turn things back to Joe Hezir, who will talk a little bit about one more component of the Mission Innovation effort.

Joseph Hezir

Okay. Thank you, Lynn. All of the programmatic initiatives that Dr. Orr described were building off of existing programs in the department that we're hoping to expand and further evolve. In addition to that, in the FY2017 budget, we did have several major new initiatives that we're really trying to start from scratch. The first one being something we're calling Regional Clean Energy Innovation Partnerships, which I'll talk about in a moment. Then in addition to that, we have several new initiatives working with our national laboratory system, in terms of increasing investments in partnerships through the laboratories. And I'll let Dr. Malhotra talk more about that later.

But let me talk for a moment about the Regional Clean Energy Innovation Partnerships. This would be a new initiative in the budget. We are proposing \$110 million as the first year funding. We intend for these to be large-scale multi-state regions. And we intend that these partnerships would be large consortia, based on not for profit forming, not for profit entities. And the partnerships could include not only federal agencies, state agencies, universities, industry, our national laboratories, and other entities.

And the idea would be the regional partnerships would be kind of a planning and funding entity. Would not necessarily be a research performer in and of itself, although obviously members of the partnership would be funds to actually do the—perform the research. But I think the two key characteristics that make this different than our current programs is one being that they be a regional focus. Rather than a national focus. And the second one is that they would be not technology specific, but rather they would focus on setting their own priorities among technology areas that would be applicable to the requirements, needs, and capabilities within that particular region.

And so unlike some of the other initiatives that we currently have that Dr. Orr described, like the frontier centers and the hubs, that have a specific technology focus, these ones would be much more flexible. And we would really, really rely on the regional consortia to develop the priorities for those partnerships.

To give you some idea why we think the idea of regional partnerships are important is that when you look across the United States, we do have some very large variations in our energy resources, and how we use energy, and other factors. So for example—I won't go into this chart in much detail, but I just point out that when you look across these regions of the US, you'll see we have, for example, in the electricity sector, significant differences in our electricity generation portfolio by region. We also have very significant differences in the amount of water consumption, or water use, I should say, related to electricity generation, in each region.

So this kind of relates back to the energy water issue that Dr. Orr mentioned earlier. I think it points out why in different regions that they would have different priorities, and different needs. Likewise, and, again, I'll just go through this quickly, and if you'll look at our renewable resource base, within the US, it obviously varies significantly by region with respect to biomass, wind, and solar resource capabilities.

Then last but not least, also when we look at our sequestration capabilities, where we could sequester carbon that could be captured particularly whether it be from the power sector or from major industries, we also have a very wide variation by region, in where we have capabilities to sequester carbon.

So that just kind of gives you some flavor as to why we think the idea of a regional partnership or a series of regional partnerships would be important. So let me now turn to kind of where we're at right now in terms of overall funding, and where we see ourselves headed, particularly for the rest of this year, as we're now in, if you will, the final year of this administration. And this chart shows our total science and energy portfolio, which I mentioned earlier, is in the neighborhood of \$10 billion. And of which about half of that we are counting as toward our pledge toward Mission Innovation.

If you look back over the last few years now, we really are starting out from a baseline level in FY2016, that's a very strong base level of \$4.8 billion, which is already \$300 million above where we had been in the previous two fiscal years. So we're starting already out from a very ambitious base. In our budget that we sent to Congress, we proposed a very ambitious expansion of 21 percent, or \$1 billion, which would take us from \$4.8 billion up to \$5.8 billion, in FY17. If you look at the green bars.

We've had some preliminary action by Congress in the Senate. They've actually passed an appropriations bill in the House. A bill has gone through committee. But it's been unsuccessful thus far in passing through the full House. The Congress is working under very tight budget caps. And consequently, it's allocated less money to this area. But nonetheless, we think in the marks that we've seen so far that there will be a much more modest increase, but an increase nonetheless, in Mission Innovation funding.

And so if you look at our path forward now, we think in the next six months as we complete the term of this administration, we still have a great deal of work to do. And first and foremost is obviously working with Congress in the FY2017 appropriations process. We anticipate now given the nature of the

election cycle that things will be relatively quiet in Congress between now and the November election. But we think as we approach the fall, and the end of the year, there will be an opportunity to work with both Houses as they fashion—and we are very hopeful that they will fashion a final appropriations bill for the fiscal year.

And so we will be working very hard, and the Secretary will make this a very high priority in working with the committees to further strengthen the funding that will be allocated to Mission Innovation.

Secondly, and I'll show you another slide about this in a moment, I think Dr. Orr referred to this, we are taking what we've proposed in FY17 and looking beyond that into FY2018 and the full five years, and what our full five year Mission Innovation portfolio might look like. And our objective here is to develop a more detailed portfolio plan that we can then leave as a foundation for the next administration and Congress.

Also, we're engaged currently in a number of dialogues with stakeholders. In particular, we've had very strong interest in the university community in Mission Innovation. And a number of universities have approached us in hosting workshops on Mission Innovation. In general and on regional partnerships in particular. We've had a number of these already. We have a few more yet planned during the course of the summer and early fall. And what we plan to do is put together a report, probably this fall, based on what we've learned from these various workshop meetings.

And then we—concurrent with that, we also are hoping to put together a kind of next stage kind of program design for the Regional Clean Energy Innovation Partnership Program. And we hope to then also hold some sort of a public workshop meeting sometime, again, perhaps in early fall, in looking at what our future Mission Innovation portfolio might look like.

And then last but not least, back at the beginning of this presentation, Dave Turk had mentioned that Bill Gates was working on a parallel initiative with private investors, called the Breakthrough Energy Coalition, or as we refer to it here, the BEC. And we're continuing to work with them as they begin to design their investment mechanisms. And we're going to continue to work with them in terms of how we facilitate communication and interaction so to make sure that private investors fully understand the innovation potential from the work that the government is funding, and how they can bring that to market.

And I think with that I'm going to now transition to Dr. Sanjiv Malhotra, who will talk more about the technology transitions. Let me just mention one other thing I left out here. As we move forward in developing our future portfolio, we're going to use the Quadrennial Technology Review report that Dr. Orr referred to earlier as kind of our guide to how we organize it. And this just shows you a slide as to ultimately how we intend to take our various programs and put them into a broader portfolio context based on electricity, fuels and transportation, and utilization as well as supporting research. So, Sanjiv, with that, I'll turn it over to you.

Thanks, Joe. So I'll start my presentation with four key observations. The first one, which I call optimism, is as Dr. Orr mentioned, as well as Joe Hezir mentioned, and starting off Dave Turk mentioned, that there is a very high level of optimism when we see what's happening in the world of emerging energy technologies, specifically when we look at technologies such as solar, where the cost has come down about 80 percent.

Deployments over the last decade or so have gone up by about 15 to 20X in lithium ion batteries, where the costs have come down, again, by about 70 percent, and they're almost—there are reports that show there are almost about 500,000 EVs running on or using lithium ion batteries as the primary power source. And then LEDs, which have become a commodity item, we have about 70 million LEDs deployed around with costs coming down of LEDs by about 85 to 90 percent. So there's a lot of optimism when we look at that.

Another area that gives us a lot of hope is that the emerging world, China, India, Sub-Saharan Africa, these areas, these geographic territories, are going to deploy energy technologies and do what I call a jump start in very much the same fashion they did with wireless telephones, where they went from zero landlines, or very patchy landline network, to having the largest amount of the maximum market share as far as wireless cellphone technology is concerned.

So we are seeing that trend even with distributed generation, these areas, in these nations. So that, again, is a great area of hope and optimism. Moving on, I wouldn't call it the good, bad, and ugly, but an area of concern is when we look at the two degree Celsius limit that has been set as part of the Paris talks. We all understand there's a massive need for new capital, both private as well as public sector funding, to come in. And be unlocked to achieve that particular target.

And another area, similar matter of concern, has been we look at the amount of private capital that has been going into innovation and clean energy, specifically in R&D or R&D activities as it relates to clean energy technology. Here's a figure that has been a pretty well published statistic. We see that private equity firms have reduced the amount of funding in early stage by almost about 85 percent since 2008. So these are some key areas of observation. And this will sort of set the trend for me to proceed with my talk here.

And I want to focus on two offices. One is the office of technology transition. And the second is the Clean Energy Investment Center, which is part of the OTT, or office of technology transition. And we'll talk to you as to what these two entities are working on. So the office of technology transition, or OTT, was established in early 2015. And the mandate was to create a center or office that would expand the commercial impact of DOE's activities in RD&D—specifically in research, development, and deployment. Over the short term, midterm, and long term.

And how are we doing this? We are essentially guiding policies and initiatives that are helping the Department of Energy in two key areas. One is essentially to help enhance the return on investment in DOE's R&D activities. And this is R&D activities funded by taxpayer dollars. The other key area of focus for OTT is essentially to help DOE and private companies mature and release technologies that address today's climate challenges, or even energy efficiency challenges.

So if you look at the bottom of the slide, you see some success stories. Obviously, there are a lot of success stories, but for example the 3D printing house in Oak Ridge National Labs that highlights the possibilities of new manufacturing technologies. The second one is Nanosys, which is Silicon Valley based company that has partnered with DOE's Lawrence Berkeley National Labs, and with 3M and LG, to develop quantum dot enhancement film that offers a very significant value proposition in terms of enhancing the wider color spectrum. And at compatible prices. And that is being used today in the Kindle Fire 7.

The next picture that you see at the bottom there is of a company, a startup called Blue Current that is developing lithium ion batteries with technology that came out of Lawrence Berkley National Labs, and University of North Carolina, Chapel Hill. So looking at this slide here, would like to mention that DOE has a very well established and well-coordinated pipeline of innovation. It starts from the highest level, which is the department wide, where we have programs and funding programs such as the SBIR, Small Business Innovation Research.

Then we have user facilities that Dr. Orr talked about. TCF, or the Technology Commercialization Fund. The Energy Innovation Portal, which is hosted by EERE, and NREL. And Project Database and Lab Partnering Service, which my office, or the Clean Energy Investment Center, is in the process of releasing. Then, moving to one layer deeper, when we look at centers that have been set up by the labs—for example, the Center for Collaboration and Commercialization, IGATE, and the Open Campus set up by Livermore, and Cal Charts, I will not go into all of these centers.

But more than happy to answer questions at the end of my talk, as well as post this webinar. And then one more layer deeper, we have several programs and centers which focus on various areas of research that have been developed by individual programs at Department of Energy. For example, the Great Lakes Bio Energy, the JCESR, which is between Argonne National Labs and Lawrence Berkeley Labs and PNNL. And Cyclotronward. So that gives you a very good idea of the innovation pipeline that we have developed over at DOE in order to take technologies out of our labs and get them into the commercial marketplace.

So moving onto the next slide, I will take some time to talk about both of these programs that I had just referred to. So, for example, the small business vouchers. The SBV is a pilot program that as introduced last year. And the focus is to provide a streamline portal and financial support for small businesses that are seeking to access the capabilities at our national labs,

capabilities and technologies developed at our national labs. So this is a \$20 million program, and in round one, we selected 33 vouchers in nine areas in nine technical areas.

So the overarching objective of SBV, essentially, moves from increasing the small business access to lab capabilities to broadening the mutual awareness of lab technologies, and the needs of small businesses that are seeking to work with the national labs and, very important is that this would enable our labs to develop technologies in a time scale that is very commensurate with what the private sector is looking at. So, moving onto the next slide.

I'd like to talk about another program we released this year. Technology Commercialization Fund. Or TCF. And here we have two topics. Topic one is technology is for technology maturation project, and the two key criteria for topic one is that we are looking at projects that are in the process of maturing lab technologies. And but are not there yet. And they need to have some more technology development in order to be able to partner with the commercial entity.

And topic two is providing support through a mechanism such as CRADA or some other contractual mechanism for labs or technology that have been developed at our labs, in cooperation with a private sector partner. And between these two topics, essentially, we have announced about 50 plus projects. And we just made the final selection, early part of this month. And as you can see on the slide, topic one has anywhere between \$100,000.00 to \$150,000.00 funding for a period of six months to a year. Topic two provides anywhere between \$200,000.00 to \$750,000.00. And the timeline is between one to two years.

And, again, some more details and highlights of the TCF project. As I said earlier. We have made awards of about 54 projects for a total of about \$16 million. And the labs have contributed about \$2.3 million cost share from the royalty accounts. And the private partners are contributing about \$14.8 million. They were out of the 54 projects, 26 were for topic one, and 28 were for topic two. What's very encouraging is that the 37—a total of 37 projects had private partners. And a total of 50 plus individual private partners are engaged today with TCF. That obviously goes a long way to ensure the success of an effort like the TCF, where we are looking at commercializing lab technologies.

So moving on to what the Clean Energy Investment Center is focused on. The Clean Energy Investment Center was announced last year. And I'm the inaugural director of Clean Energy Investment Center. I started in earlier part of this year. And our focus is essentially to catalyze and enable private sector investment into innovation in clean energy, especially in R&D technologies. And there are about four to five deliverables that the Clean Energy Investment Center is focused on.

First is to enable a platform that where investors can connect with subject matter experts within the DOE ecosystem. Whether this is at our 17 national labs, or within the DOE's program offices. And we call that the Lab

Partnering Service. The second one is just jumping here from the first to the third, sorry, first to fourth, is Project Data Initiative, which we are looking to announce in the next few months. That's again an online portal that would provide information on technologies that have been funded by DOE, either developed at our labs, or through our program offices.

And the next one is—would be called LINKS or Lab Investor Knowledge Series, or Seminars. And these are meetings that are held between investors and subject matter experts, as well as other technology transition personnel from our various labs. And the focus of this is to enable more public private, more public investor partnerships. Similar to that is the Innovation Interface, or what we call the I2. These are sessions we have been hosting here at the DOE headquarters between investors, private sector community, as well as our program offices and subject matter experts within our program offices.

And the last one is technical assistance. We at DOE are putting out lot of information in the form of reports and whitepapers on technology and markets. And we are looking at streamlining that effort so these can be provided to the investor community, and enable them to make more intelligent decisions on investments in clean energy R&D. Thank you.

Sean Esterly

Great, thank you everyone for the great presentations. We will proceed now to the question and answer session of the webinar. Just a reminder, to any of our attendees, that if you have questions for our panelists, go ahead and type those into the question pane, and we will receive those and present them as they arrive. So at this point, we will open the floor up to all the speakers. And it's just an open discussion, based on the questions that were submitted to us. The first we received is asking—to what extent can non-US companies participate in DOE initiatives and resources?

Franklin Orr

We're having a debate as to who wants to answer. As we define specific funding opportunity announcements, the conditions that apply for those will be specified at the time—we understand the Mission Innovation effort as being ones that are largely organized within each country, around the world. But we also recognize there will be some opportunities for joint work. And so the details of that are certain to be worked out as we go along with it. But all of that's not set yet.

Sean Esterly

Great, thank you so much. We'll move along to the next question. It comes from one of our attendees in Denmark. They note that they assume that the EU baseline RD&D figures are not included in the diagram shown earlier in the presentation, but how do you intend to handle the required _____ of budgets for the EU by 2021?

David Turk

So this is Dave, and thanks for the question from our Danish colleague. The figure we talked about, both Joe and I talked about, the \$15 billion cumulative baseline, actually does include the EU budget. Which is about \$1 billion US, roughly, currently, and then doubling to \$2 billion over time. And so that \$15 billion figure includes the US funding that Joe, Lynn, Sanjiv have talked about. It includes all other country partners, including the EU, as well. And

the EU budget is above and beyond what the EU member countries are bringing to the table as well.

All of this can be found in detail. Each country has a separate part of the mission-innovation.net website, in which you can see the particular baseline for each partner, each government partner, as well as a narrative on their doubling plan.

Sean Esterly

Great, thanks again. One of our attendees noted that in the last of Joe's slides there was a reduced funding for nuclear energy. He was hoping you could talk a little bit about the reasoning behind that.

Joseph Hezir

Yes. There are two factors behind that. One was that in the FY2017 budget, we put a substantial amount of resources within the nuclear energy budget into the completion of the design certification project for the small modular reactor program. And because that funding was going toward cost sharing of design certification, it was not counted as R&D, so it doesn't show up there, but it—there was a substantial increase there.

The other reason why that number went down is one of timing. As I mentioned earlier, in FY17, as you saw from the earlier slides, we tried to emphasize some of the earlier stages, investment in some of the earlier stages in the innovation pipeline. And we would see more monies flowing into the applied areas, such as the nuclear energy program, as well as the fossil energy program, within the five-year time horizon. And one of the things we're going to be working on now, as I mentioned at the end of my presentation, is we're looking right now to begin to put together what we think the five year detailed portfolio would look like, and we would expect to see some increases in those wedges over time.

So the FY17 change is a little bit of an anomaly, quite frankly, but probably when you look at the full five-year projection, which we will have, later this year, you will see a different picture.

Sean Esterly

Great. Thank you for the response. Move along now to the next question. This one asks—how can non-profit incubators and accelerators work with DOE to pursue Mission Innovation's initiatives?

Franklin Orr

Well, I would say—this is Lynn Orr—that the structure that we're thinking about for our regional innovation partnerships are likely actually to be a non-profit entity that could easily be a consortium of other organizations like universities, perhaps with industry support, and some other non-profits. So there is every reason to expect that the non-profit world would play a role in this. And of course they do play already in all the kinds of research things that we sponsor from our program offices. So I would guess that will continue.

Sanjiv Malhotra

And to add to that—this is Sanjiv—I think we already have a program called the Innovate Energy, which has got incubators involved in the clean energy—or accelerating and incubating clean energy projects.

Joseph Hezir

And this is Joe. I'll just chime in as well. Going back to Lynn's point. The entities such as non-profits and incubators and those types of entities, we would see them playing a very important role in the proposed regional partnerships. Because we would see the regional partnership as being the place where we would really want to _____ marry together very closely the research activities going on in—whether it's universities, or industry, and taking that, and connecting it into the deployment phase.

And we would see, for example, that perhaps in some cases maybe the federal money wouldn't necessarily flow into the incubator, but by having it as part of the partnership, we'd see the partnership as well as having links to state and regional economic development programs. Programs such as state green banks, and clean energy financing mechanisms. And so we're hoping that the partnership then becomes sort of an anchor, and a seed, for bringing together all of these kinds of activities, reaching out beyond just simply the research and development phase, and really tying together the entire innovation cycle.

Sean Esterly

Thank you again. I'll move along. The next question. This attendee points out that as mentioned last week during the Global Entrepreneurship Congress, the panel discussed further the plans to facilitate opportunities for leading clean energy investors to evaluate and consider providing seed funding and similar investments to these entrepreneurs, building in part on the work and vision of the Breakthrough Energy Coalition. And I'm happy to repeat that if you need me to.

Sanjiv Malhotra

Yeah, could you please?

Sean Esterly

Yeah. Certainly. So, as mentioned last week, during the Global Entrepreneurship Congress, could the panel discuss further the plans to facilitate opportunities for leading clean energy investors to evaluate and consider providing seed funding and similar investments to these entrepreneurs, building in part on the work and vision of the Breakthrough Energy Coalition?

Sanjiv Malhotra

Sure. This is Sanjiv. I'll address that question. So as I mentioned in the last slide in my presentation, the Clean Energy Investment Center has several products and services we're working on, starting with connecting brain trusts to investors so that they could get some insight into technologies to moving onto projects as part of the project database, where there could be an understanding of what the projects entail, and the technologies that are being worked on, the challenges that are being addressed. And other soft touches, such as activities such as LINKS, etcetera. So the DOE and the Clean Energy Investment Center, we are working on making sure that investors whether it's Breakthrough Energy Coalition, or various other investors.

So we obviously work with a multitude of investors. We want to ensure that we can provide all this information that would enable a seamless transition of technologies, not only from our labs, but various other entities that have been funded by DOE, so we can see an enhancement in the pipeline of technology that are funded by these investors. And one of the key things is these investors need to understand that this is going to require longer time horizons,

as opposed to what we saw back in 2008-2010 timeframe. So all this effort will go towards enhancing the understanding of technology risks, market risks, etcetera, so we can have better decisions made by investors.

Sean Esterly

Great, thank you very much, Dr. Malhotra. Next question asks—can you speak to whether the DOE plans to specifically resource any international RD&D collaboration, for instance by building upon existing partnerships with international partners?

David Turk

Thanks for the question. Let me start, and then Lynn, whose office coordinates a lot of these more directly. First thing to understand, of course, or to point out, is the fact that the US and DOE in particular are involved in a number of international collaborative partnerships, variety of different flavors and formats to them. We have a bilateral research effort with China called the CERC. We also have one called PACE-R, with India. But that's just a couple examples.

And there's a number of other different varieties that we're involved in. The way our Secretary of Energy talked about this at the ministerial, the international collaboration pieces, we've got all these countries, 21 governments, making this commitment to double clean energy R&D. Each country will determine for itself what its budget is, what its portfolio is, as Joe and Lynn walked through in some detail, in the presentation, today.

But there will also be a set of conversations that we hope the Mission Innovation platform provides the opportunity for countries who are interested to collaborate, to have discussions, to organically figure out different priorities they may be interested in working on, to be able to share some models and expertise among ourselves. Then, as Sanjiv has certainly pointed out, and Joe got into in his presentation as well, and actually Lynn you mentioned this in yours as well, it's not enough for the government to obviously produce some technological solutions if those don't get to market and don't get to scale.

So the public private piece of this, the investor piece of this, the company piece of this, is absolutely critical, going forward, as well. Lynn, anything else you want to say on the—

Franklin Orr

Yeah. I would say it seems very likely that pairs of countries will have common interests in a particular research area, with each contributing work they are doing in their own programs, that communication amongst those, and perhaps joint bilateral work, might very well make some sense in that. We're not anticipating there'll be a worldwide research planning exercise, but we recognize that opportunities will exist, and we expect that countries will work out sensible arrangements when it makes sense to do so.

Sean Esterly

Thank you both. Going back now to the question on the EU. Our attendee from Denmark wants to know—they do thank you for the clarification concerning the EU baseline budget. They were wondering if you had any insights onto how the EU will be able to double its already large RD&D budget by 2021, as called for.

David Turk

Thanks for the question. I think probably most appropriate would be to put this Danish colleague directly in touch with our European Commission Colleagues as well. There is more information on their own doubling plan on the Mission Innovation website. The answer may be there as well. It is, as I understand it, a seven-year budgeting process, in terms of how the EU does this, does this kind of thing, as well. So part of these decisions have already been made, but future decisions will need to be made as well. But if our Danish colleague wants any further information, certainly look to the website first. And I'm happy, as the interim secretariat for Mission Innovation, the US Department of Energy would be happy to put him in touch with the relevant colleagues in the European Commission.

Sean Esterly

Perfect. Thank you. And I'll pass along that information through email following the webinar as well, so we can follow up on that. So at this point, that is all the questions that have come in from the audience, and what's left is a brief survey for our attendees. Before we head on to that, I wanted to give one last opportunity for any closing remarks or final statements you might have.

Franklin Orr

This is Lynn Orr. I'd just say that I think we should all be encouraged by the willingness of 21 nations, well, 21 entities, to tackle the energy innovation area as an important component of satisfying our Paris commitments. That there is a sense that we're moving in a very important way, in the right direction. That's not to minimize the magnitude of the challenge we have to deal with going forward, but we need all the players we can get on the field. And we need them to be distributed around the world in programs that make sense for their own nations. So this is an opportunity for all of us to contribute in an important way on something that really does matter to the planet, and we should take full advantage of that.

David Turk

This is Dave. Just to underscore what Lynn said. It's quite remarkable, I think, to get 21 governments, major governments developing wide range of diversity across the world, to make this kind of political commitment to double budgets, and at a time for many countries of very challenging budget circumstances. But to double those budgets over a relatively short amount of time, five years, it shows I think some tremendous political leadership in these countries. But I think also underscores the tremendous opportunity here from technology innovation, and from really taking advantage of this moment in time to really double down on this, not only as a critical part of the climate challenge, but also as a critical economic driver, going forward, promoting energy security, etcetera.

And it's not just the governments. But you see the private sector really stepping up to the plate. The Breakthrough Energy Coalition, which, as Joe mentioned, is an independent but complementary effort to Mission Innovation. And all the colleagues that Sanjiv is working with, both investors, businesses in the US, and elsewhere, also stepping up to the plate, and certainly there's a terrific opportunity for all of us to take advantage of this moment in time, all to the better, going forward.

Just one last logistics piece. We are playing currently the secretariat role for the broader Mission Innovation effort. So if there are additional questions people have about the global effort where Mission Innovation as a whole is headed, above and beyond what the US contribution is, certainly feel free to email us at the Secretariat@Mission-Innovation.net email address, and we'll be happy to provide any further information.

Sean Esterly

Great, thank you so much again. I hate to backtrack a little bit but we did have an interesting question come in that I think would be of interest to a lot of our audience members. I wanted to go ahead and ask that to the panelists, if I could. It's the attendee is curious if the panelists have any thoughts and expectations on what can be achieved at COP 22 this November.

David Turk

Thanks for that question, and we've been working very much hand in hand with other US government colleagues, our Moroccan colleagues who are hosting COP 22 in November, as well. I think there's a variety of different answers to that question. Certainly from the negotiations perspective, it's our State Department who leads those efforts. I'm not going to speak on behalf of Special Envoy Jonathan Pershing. There is some follow up efforts that need to be done on that piece, following up the Paris COP.

What I hear, not only from other governments, primarily, but other businesses and other civil society, is we really need to shift to a world of implementation now. And there seem to be two major questions coming from the Paris COP, terrific success that it was, getting all the countries of the world, getting consensus among all the countries in the world for this process, this structure, this platform, to take us forward.

But the two key questions are, one, great, we've got these, in many cases, quite ambitious targets on the table in the medium term to 2025, 2030. Key question there is how do you go from paper targets, paper ambition, to real world implementation. And so that implementation piece is absolutely critical, and I think recognized as the key next step that we really need to keep the momentum going forward.

A second question which I think fits in quite centrally with Mission Innovation is even if you were to fully implement all of those INDCs or NDCs, Nationally Determined Contributions, a number of analyses have already been done, and that doesn't get you to the shared goal of two degrees Celsius. The level that we need to reduce emissions, going forward, to avoid the worst consequences of climate change. We're just not there yet in terms of the ambition on the table.

So the question is, how do you take advantage of this five-year iterative cycle that the Paris COP set up so that countries and others can be more ambitious over time? And I think one central answer to that is technology innovation, to develop those new technologies to keep reducing those costs, to change the reality on the ground of what's possible, not only in countries like the United States, other developed countries, but, as important, and in some ways more importantly, throughout the world, in countries like India and Africa.

As Sanjiv said, to leapfrog technology is to change what's possible. Not only to reduce emissions but to promote energy access and energy service throughout the world. And so there needs to be an effort on how do you fill this ambition gap? How do you make sure we're changing the reality on the ground throughout the world so that our political leaders can be more and more ambitious every five years? And, frankly, I think Mission Innovation provides a terrific opportunity as one part of that solution for raising ambition over time.

Sean Esterly

Thank you so much, Dave, for that response. So now we will proceed with the attendee survey. We just have a couple brief questions that help us evaluate how we did and improve for future webinars. So attendees can respond to this directly through the platform. And the statement is—the webinar content provided me useful information and insight. And the second statement—the webinar's presenters were effective. And the third statement—overall, the webinar met my expectations.

And then we just have two yes or no questions for the attendees. The first is—do you anticipate using the information presented in this webinar directly in your work and or organization? And the final question for the survey is—do you anticipate applying the information presented to develop or revise policies or programs in your country of focus?

Thank you so much, everyone, for answering our survey. And on behalf of the Clean Energy Solutions Center, I'd like to once again extend a thank you to each of our panelists today for taking the time out to participate. And also want to thank our attendees for participating in today's webinar. We very much appreciate everyone's time. I do invite our attendees to check the Solutions Center website, if you'd like to view the slides, and listen to a recording of today's presentations, as well as any of our previously held webinars.

Additionally, you'll find information on our upcoming webinars and other training events being hosted by the Solutions Center. And, just a reminder, we're now posting webinar recordings to the [Clean Energy Solutions Center YouTube channel](#), where you can find a nice library of other videos. Please allow about one week for the recording and presentation to be posted. And we do invite everyone to inform your colleagues and those in your networks about the Solutions Center resources and services, including the no cost policy technical assistance support.

With that, I hope everyone has a great rest of your day, and we hope to see you again at future Clean Energy Solutions Center events. This concludes our webinar.