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>> BEN BROWN: I'd like to invite everyone to take their seat. We're going to get started momentarily.

Good morning. I'd like to welcome you to the U.S. Department of Energy's batteries and energy storage research information meeting. Just a few quick administrative announcements before we go into our regular program. If you have not picked up your name badge, please see either Margie or Katie in the lobby. In the unlikely event of an emergency, we'll exit through the rear doors. There's a patio out the glass doors. Exit through the glass doors and there are steps leading down to the outside. As you know, this meeting is being webcast live and the archived video will actually be available for one year (correction).

A transcript of the meeting is being produced and the transcript, the presentation materials that will be shown this morning and the comments that are being submitted online will all be archived on the meeting's website.

For those submitting comments online, that facility is now open and we invite all of those online to submit comments. That web portal for the comments will be open for seven days and will close 5 p.m. eastern time next Friday. We invite those comments to come in as soon as you can. If there are lulls in the afternoon's comments sessions we will read comments that have been submitted online during those sessions.

I would like to invite Dr. Patricia Dehmer, the Deputy Director for Science Programs in the Office of Science, to kick off the proceedings.

PATRICIA DEHMER: Good morning. Welcome to the meeting. I'm here representing the Office of Science, but I'm going to give you just a little bit of background on what's going to happen today. You can see from the agenda that's up on the screen that today's meeting has two very important elements. The first is that several of the program offices are going to brief you on research that's going on right now in the area of electrical energy storage. And second, and very importantly, the entire second half of the meeting is going to be open for comments from the field, both people here today, and people who are watching this on webcast. We solicit comments on a number of specific areas to help us understand the goals of the research in the field and where you think this area ought to be going. So getting back to the Office of Science, which I represent, as you know, beginning almost ten years ago now in 2002 the Office of Science through its Basic Energy Sciences program launched a series of workshops with a generic title basic research needs. The first level was done under the Federal Advisory Committee Act and it was called Basic Research Needs to Assure a Secure

Energy Future. And coming out of that very first workshop was a priority research direction called innovative energy storage. And that first workshop launched a series of about ten more workshops, actually more than that by this time, and one of those workshops in 2007 was specifically devoted to energy storage, electrical energy storage. And more recently, a couple of years ago, there was another workshop from the Basic Energy Sciences program called science for energy technologies. And from the Office of Science you'll be hearing some of the results this morning on the outcomes of those two workshops.

In addition, you'll hear from the energy technology programs and also from ARPA-E. So energy storage in the Department of Energy is very much a cross-cutting issue across all of the parts of the Department. There is strong integration among those different parts and this morning is devoted to telling about the parts and a little bit about the integration.

So as you know, the Energy Innovation Hubs is a signature activity of this particular Secretary and, since he came to the Department, he has been pushing things like Hubs, creatures like Hubs, and, several of them have already been solicited and awarded. The Batteries and Energy Storage Hub is one that's being considered in the very near term. And so our discussions to you and your input to us will really help inform us on what that should look like.

The Secretary was informed by the concept of a Hub which integrates basic and applied research from his years at Lawrence Berkeley National Laboratory and from the Bioenergy Research Center that was awarded. He's committed to the idea of R&D integration and having a single entity that under one roof combines basic and applied research. So that's why we're here today. That's why you're here today. And on behalf of the Office of Science, I welcome you to this meeting and look forward to your thoughts and comments. With that, I'm going to turn the proceedings back over to Ben. Thank you.

>>BEN BROWN: I think I did forget to give you my name. I'm Ben Brown, senior science technology advisor in the Office of Science. I'd like to welcome Colin McCormick, Senior Advisor for R&D in the Office of the Under Secretary.

>> COLIN MCCORMICK: Thank you, Ben. Good morning to everyone. I'd like to add my welcome to all of you that Pat just extended. I'd like to give you a few thoughts about the integration and coordination across the Department that's been a hallmark of our efforts over the last year or so.

I can start perhaps by commenting, I think everyone in this room recognizes the importance of the subject today. Batteries, energy, storage cross the energy technology

landscape from the grid space through the renewable energy generation space into transportation.

Within the Office of the Under Secretary, which I represent here today, we have general oversight of the core applied technology or energy technology programs. These are the Office of Energy Efficiency and Renewable Energy, Office of Electricity, Fossil Energy and Nuclear Energy. Today EERE and OE are the primary relevant ones. The applied programs address fundamentally the supporting applied R&D and energy technology and a number of different stages from the component development and engineering stage through the systems integration testing and validation stage and to the point of infrastructure analysis around resources and economics spanning the supply side of the issue and supply side of the problem.

They're heavily use-inspired, target specific technology challenges - where there's a need that exists in the marketplace today or is likely to be in the near future marketplace. The focus is primarily on technology with the greatest likelihood of near- and medium-term impact on the systems. I guess one way of characterizing this is an effort to make steady and consistent progress along existing technology and cost learning curves today.

The relatively new ARPA-E office which we'll hear from today is also of course heavily use-inspired. But its focus is primarily on technology white space, areas or projects that are too risky for the main applied technology programs to address. They clearly embrace this level of higher risk which will necessarily result in a higher failure rate, but those projects that do succeed will then fundamentally disrupt the learning curves and technology paradigms that are present in the market today.

Both the core applied energy technology programs build on the core progress and fundamental scientific understanding from the Office of Science which we heard about from Pat earlier and will continue to hear about today. I think the main message I want to leave you with today is that these three modes of addressing technology challenges in the energy space are deeply and fundamentally complementary. You're going to hear from representatives of all three modes today and I hope that these will give you a full spectrum view across the Department of what we're doing in this space. And then also represent our new robust recommitment to coordination across these different parts of the department.

The only thing I'd like to leave you with, then, before we get into this is that we're very happy to have all of you subject matter experts here today to help give us feedback and comments as we continue to consider both our coordinated R&D efforts across the Department and as we contemplate this new proposed initiative around the Energy Innovation Hub in Batteries and Energy Storage. Thank you very much and I'll turn it back over to Ben.

BEN BROWN: All right. To lead off the technical presentations, that are featured this morning, I'd like to introduce David Howell. He's the Team Lead for Hybrid Electric

Systems in the Office of Energy Efficiency and Renewable Energy in the Vehicle Technologies Program. He's the manager of the Vehicle Technologies Battery R&D portfolio and he's also been the manager of the Recovery Act Battery Manufacturing grants. So Dave?

DAVID HOWELL: I'd like to extend my welcome to everyone this morning. It's a pleasure to be here. I have quite a few slides so I'm going to jump right into this presentation, but I do look forward to your feedback this afternoon in terms of your ideas and thoughts of where we could be headed or should be heading in terms of battery research and development for transportation batteries for electric drive vehicles. This presentation covers quite a few things and one of the things that I think Colin mentioned was an integrated tech team that we've developed here to focus our attention between the offices that are funding research and development in this space. So this presentation has been supported in its development by not only the vehicle technologies program but also ARPA-E and the Basic Energy Sciences programs.

So let me just jump into why we do what we do and I think everyone is familiar with this. We are dependent upon petroleum for transportation energy. If you look at our petroleum dependence today, we're going to basically consume 20 million barrels of oil each day. And 72 percent of that will be for transportation, and of that, 80 percent will be for on-road use. Also couple the additional problem: our transportation sector is 94 percent dependent upon oil. So we have a significant problem, and electric drive vehicle architectures in the transportation system provide two benefits. One is extremely high efficiency systems, which translates into higher fuel economy, and also displacement of the petroleum through the use of electricity.

Another issue we have is it takes a long time for technologies to penetrate the market in the transportation sector. We have about 240 million light duty vehicles on the road today. And we're introducing about 12 to 15 million new vehicles every year. It takes 15 to 20 years for the entire fleet to turn over. Given also that it takes quite a bit of time for any new technology to actually significantly penetrate the market, again, ten to 15 years on that side, we need to get started today and we need to drive technologies into the automotive sector as fast as we can, and that's what we're trying to do within the integrated program at the discharge.

Of course electric drive vehicles as I mentioned can provide significant benefits in terms of fuel economy and petroleum displacement. Our focus here is on three different architectures of electric drive vehicles. One is the conventional hybrid which is like the Toyota Prius, a high powered battery with an incremental cost of $1,200 to $1,500 for the battery. As you can see, you can get significant fuel economy improvements with the hybrid. We also are focusing a lot of our attention on the plug-in hybrid vehicle which is a combination of an electric vehicle with a high power hybrid system; typically we're looking at electric drive vehicle range of 10 to 40 miles all electric range, and then at that point the vehicle would operate as a hybrid vehicle.

Again, you're looking at a large battery for this, 16-kilowatt hour versus the one kilowatt hour battery for the HEV which introduces a significant cost challenge for us.

The third architecture that we're focused on is the all electric vehicle or battery electric vehicle. Again, it's obviously using electricity instead of petroleum for propulsion. You're looking at a significantly larger battery. This battery is around 24 kilowatt hours of rated capacity. And you're talking about a $15,000 cost increment there. In order for us to achieve large national benefits in terms of transportation electrification, we need significant market potential penetration and the battery affordability and performance are keys to this.

As I mentioned before we do have an integrated tech team at the Department that's coordinating our work and goals in this area. Here's a snapshot of organizations or offices within the department that are funding battery research that are relevant to transportation vehicle batteries. Out of the Office of Science the Basic Energy Sciences programs are funding research, ARPA-E and EERE, through the Vehicle Technologies Program. We coordinate to make sure that, number one there's not unnecessary duplication of efforts in our program but also we're coordinated in terms of goals and targets and technologies that we're pursuing. But as you see here, the Office of Science is focused on fundamental research to understand and protect and control matter and to understand electrochemical phenomena and basic material discoveries. The ARPA-E is looking at high risk transformational research that's got the potential to significantly move the needle in terms of market acceptance of new technologies, and the vehicle technologies program is applied battery R&D program again focused on electric drive vehicle batteries and technologies that would enable a large market penetration of electric vehicles.

Most of this presentation at this point will, number one, be the goals that we've set for ourselves as an integrated tech team and then focus on the vehicle technologies program portfolio and I do have a few slides on ARPA-E's portfolio and then John and Linda will a little later this morning have a focus presentations on the Basic Energy Sciences work.

So in terms of Basic Energy Sciences, as I mentioned, they're look at new material discoveries, looking at materials structures and interfaces and electrochemical phenomena. The Vehicle Technologies Program is an applied program where we've focused our efforts on developing new materials such as cathodes trying to understand material specifications and increase capacities of materials and develop materials that are relevant for electrodes and vehicle batteries.

We also do quite a bit of work in what we call high power and high energy cell R&D batteries. You see a lot of materials advancements, but of course the battery is an electrochemical system and this is where we try to optimize the electrochemical system of the battery. This is both a laboratory and industry effort. Most of our advanced materials research is mostly a laboratory and university effort.

And finally, we work with the auto companies, the industry, battery companies and materials suppliers to develop robust electric drive vehicle batteries. We do a lot of testing analysis and design work in this area, and it's pretty much focused on not only establishing [and optimizing] the performance of a certain technology but driving down the cost of that technology.

So as you see, Basic Energy Sciences works in this space. ARPA-E typically wants to take the new material discoveries and push them as far as they can over through the TRL levels and this is the role the Vehicle Technologies Program plays.

In terms of energy storage budget across DOE, over the last three years the Department has invested significant funding into electric drive vehicle batteries. As you see here, the we typically on an annual basis are hovering around $95 million a year and we also have investments from ARPA-E from the 2009 recovery act and this doesn't include the battery manufacturing grants, that was $1.5 billion worth of grants to establish battery manufacturing in the United States that was matched by industry and electric drive vehicle deployment activities. So as you can see, we have significant funding going into this area so it's very important for us to coordinate our work.

One of the primary objectives of the integrated tech team is to develop an overarching goal [for energy storage development] and our team [developed] the one penny a mile goal seen here. We call this “winning the race for a better battery.” What you've seen over the last three or four years is that this is an international race. The Japanese, Chinese, Koreans and the Europeans are all gearing up to win this race. So it's very important for us to make a concerted effort so that the United States doesn't fall behind and maintains our progress in this area.

So the one penny a mile goal basically works itself out this way. [It is determined by dividing the] initial battery cost by the total electric miles driven, and typically we want a battery that's going to provide 150,000 mile range over its lifetime. So this would address what we consider the consumer's concerns about battery life and about battery cost.

And if you take a look at the different vehicle drive architectures that I've listed, a battery in a plug in hybrid vehicle that can allow you to drive 40 miles in an all-electric range, that's basically about 12 kilowatt hours of usable energy, [and works] out to be one penny a mile or $1,500 for that battery. This is a significant achievement since we're typically somewhere around $8,000 to $10,000 for that type of battery today.

And in terms of an EV100 battery, an electric vehicle battery that would allow you to travel 100 miles in all electric range works itself out to be about two pennies a mile. And a long range EV battery capable of propelling a vehicle for 300 miles, roughly 60 kilowatt hours of usable energy , would cost five pennies a mile or $7,500 which now begins to be very competitive with conventional vehicles.

But we also understand that more than cost and battery life are barriers in terms of these vehicles.

What we call range anxiety is also an issue with the consumers. So we decided that as a program, we needed to develop a goal in [for] fast charging. So in terms of looking at what the capabilities are today [for] fast charging, we typically use a 50-kilowatt charger, and for a Leaf-sized battery that works itself out to about five miles a minute. So we wanted to push that envelop a little bit and we [developed] a goal of “ten miles per minute.

Total charge time, would obviously vary based on the vehicle architecture and the battery size. For a plug in hybrid vehicle traveling 40 miles we don't really think it's that relevant, four minutes versus a couple of hours. I'm not sure that it's going to matter. But for the EV100 battery and the EV300 battery it's going to be very important. The EV100 battery could be recharged in about ten minutes. And the EV 300 battery could be completely recharged in about 30 minutes. This is pretty much a stop at a gas station today and with the EV 300 charge you may want to take a little rest at that gas station, but still we think that would alleviate a lot of the range anxiety that's a prevalent barrier in terms of electric drive vehicle commercialization.

So how does this work out in terms of what type of charger you would need? , Instead of a 50-kilowatt charger, [you would need a] 180-kilowatt charger, [which is] doable in terms of engineering specifications. There [are] also other goals that we want to focus on. We want the battery to be safe. So to assure consumer confidence, we want it constructed of earth abundant materials that would be required for low cost and eliminate resource dependence as will recyclability for environmental steward ship and to assure critical material available and cost.

Let's go into the technologies that we're focused on in our programs. This chart pretty much depicts a materials roadmap. Everything's not depicted on here. We hope for new materials discoveries coming out of Office of Science Hub in the future. But pretty much this is the landscape today. The lower left-hand corner you see the conventional technologies, the graphites with the lithium ion nickel based cathode or iron phosphate type cathode. Our programs have moved beyond that. No work really is going on in these areas at this time except for benchmark testing and things of that nature to make sure that we understand what the state of technology is. But we're moving up these four bars, specifically going to higher voltage and higher capacity cathode materials, high voltage cathode materials, replacing the graphite anode with a silicon or metal alloy anode and moving to the lithium metal and polymer batteries and lithium air batteries. We have programs that cut across all of this area. These [materials are at] different TRL levels.

For the VTP program we put most of our focus on the lithium ion systems at this time. That doesn't mean we don't fund work in the lithium sulfur and lithium metal systems, but that's our primary focus. If you overlay where ARPA-E is putting their money it's mostly in the lithium metal systems but they also have work in the lithium ion systems

as well. In terms of basic energy sciences, it cuts across all of these technologies looking at interfaces and chemical reactions related to energy storage and new material discovery and electrochemical phenomena.

Just lining these technologies up, the first line basically is where we are today. The typical PHEV40 battery is about 80 watt hours per kilogram. The point of this slide is that we have technologies in the pipeline that we're developing that can significantly push the needle on the performance and the cost of current batteries today, whether it's future generations of lithium ion or lithium metal polymer, you can see great potential benefits for all of these systems. But with those potential benefits, come significant barriers and each of these systems have different types of barriers. Our programs are focused on overcoming each of those barriers while maintaining the performance and the potential of all of these systems.

So let me run through a few slides in terms of the VTP effort on battery and research development. I apologize to some of you that have seen these slides before. Bear with me as I go through them. And for those who have not seen these slides before, I apologize because I'm not going to spend a lot of time on each one. There's references in places where you can get more in-depth information on any of these areas, but, again, our program in vehicle technologies is focused on enabling the market success of the electrochemical energy storage technologies and basically that means increasing the performance while decreasing the cost and meeting the volume and safety requirements of the battery. You have to do that at the same time. You can't do one and not the other.

You find some chemistries that are strong in one area and weak in the other. So you basically focus efforts on that electrochemical system where it's weak while maintaining your increasing performance. We do have a goal in 2014 to reduce the production cost of PHEV batteries by $300 per kilowatt hour which represents about a 70 percent reduction from where we were, roughly $1,000 per kilowatt hour in 2008. Our overall goal is the 2020 goal for the penny a mile target which works itself out to $125 per kilowatt hour usable energy of the battery and that's at the pack level not the cell level. These are very challenging goals, but we see pathways to meet them. So that's what our programs are all about.

The budget is divided into battery development efforts, applied research and exploratory research efforts and I've got slides on each one of these areas.

[The] first thing we want to do is make sure we're working on the right targets at the vehicle and the battery level. So in our full system development program, we established the R&D targets for the battery pack such as for EV pack and a cost target of $125 per kilowatt hour. When you say an EV pack, what does that mean? It means you need a certain amount of the power from the battery, a certain amount of capacity. You have a lot of operational conditions that you have to meet and weight and volume goals as well. All of those are contained in our requirements for an EV battery for different architectures of the electric vehicle. Same thing for the PHEV systems and the

HEV systems. All of these targets can be found on our website. These targets are a little too long to list in a meeting like this, but you can do some background investigation and see what our targets are. But the bottom line is that we [conduct] a lot of simulation of vehicles, simulate the batteries and how they're operating in the vehicle to determine what our performance targets are and of course we do a lot of cost modeling on the batteries to determine what our cost need to be.

But the pack level requirements cascade down to cell level requirements, and then the cell level targets cascade down to cell material level targets. And then, of course, many of the issues that we're up against at the material-level cascade [down] to scientific exploration.

So in terms of full systems development, this is where we try to develop robust systems to meet our targets, our pack level targets. We do a lot of the work with the battery manufacturers OEMs and material suppliers. Once we develop the vehicle level requirements and understand how the battery needs to operate we'll develop robust testing protocols.

We also support a lot of R&D to develop those robust systems. The typical work in this area includes the materials specifications that are necessary, the material synthesis techniques, electrode design, electrode formulation and coating technologies. Cell design and fabrication all come into play with different technologies. Of course we work this all the way down to developing battery control and safety devices. And this is where we do our detailed cost modeling based on the performance that we're getting out of the batteries and the technologies that we developed. You can see a list of companies here at the bottom that we're currently working with. This list changes from year to year of course, [and] we use the data coming out of this program in order to judge where we are in terms of battery cost.

In terms of the high energy and high power cell research and development: [the battery] is an electrochemical system so new materials need to work together inside the cell. So you need to match an advanced cathode with the electrolyte and the advanced anode in order to reach its potential. This activity right now is just a lab activity: you see the labs that are working in this [activity listed.] Here is where we start our effort in terms of optimizing advanced materials for cell applications. We start with electrode and cell modeling and design, we'll fabricate electrodes and cells, do performance and aging tests on them and then what we call post mortem analysis to assess why did the cell fail and then develop ways to mitigate failure. Our focus will be on the higher capacity cathode materials, the lithium rich nickel manganese cobalt and a [focused] effort to develop high voltage electrolytes and additives.

[We are also developing the next generation] cell technology. We just awarded several contracts to not only focus on developing the cathode materials for battery cells but also [developing] the anode materials toward the higher capacity anodes. [Graphite exhibits just over 300 milli-amp hours per gram of capacity.] Silicon can provide much more than that, upwards of 900 milli-amp hours per gram. So here's a list of recently awarded

contracts. These are getting under way this month and most of these are in the lithium ion area and focused on developing advanced cell technology. You see the goals here using some type of silicon or silicon metal alloy anodes. You also have to pay attention to the electrolytes too.

We've also awarded a project for a lithium metal anode development at Penn State University focused on developing lithium sulfur cells.

In our advanced materials research, our exploratory research program, this is where we perform the research on new materials and then address the fundamental chemical and mechanical instabilities of those materials. Here's a sample of some of the work we have going on in this program such as using computational tools to rationally design materials. Professor Gerbrand Ceder [MIT] is the PI on that project.

A lot of our work in the materials area is based on size and morphology control of the materials, and here's an example of work by Professor Yi Cui of Stanford using silicon anode tube showing greatly enhanced cycleability. Electrode design is very important. By designing electrodes with thicker coatings, you can design them with more active material and less inactive material and increase the energy density of the cells which can drive the cost of those cells down.

Here is [left side of slide] what we are focused on in this activity over the next several years. In this program we are developing advanced anode [material] like the intermetallics and conductive additives and studies to tailor the SEI interface layer in order to improve safety and life of the batteries.

[Regarding] advanced cathode materials, this program is focused [on continued development of] the layered-layered oxides, the metal phosphates such as the cobalt phosphate and the magnesium phosphate and the metal silicates. [We are also developing the] next generation electrolytes, such as, the high voltage electrolytes, solid polymer electrolytes for lithium metal and non-flammable electrolytes. The list on the right side of the [slide shows the] current participants of this program: roughly six national laboratories and about 15 universities are participating at this time.

All of these projects are competitively selected, by the way. We typically focus our efforts on one of the material components each year. [Last] year we focused on new cathode materials. We haven't announced awards yet. In this fiscal year we'll focus our RFP on advanced diagnostics, modeling, and the assembly of battery materials and electrodes. I want to [mention that] we also have an open solicitation for new ideas. Here's the website to look for [information on] how to propose new ideas.

So moving on to technologies beyond lithium ion, we also work in lithium metal and polymer. These technologies offer revolutionary energy density and major cost reductions but they have significant barriers that we're addressing: [such as] the lithium metal dendrites that develop in lithium metal leads to cells shorting, the polysulfides [development leads] to self discharge and poor cycleability in the lithium sulfur systems.

Lithium air systems are very low in efficiency right now and they need a good bifunctional catalyst, and all these systems typically suffer from poor power, so we have R&D programs focused on mitigating those issues. Here's a list of projects that are focused on inhibiting dendrite growth both SEEO and LBNL, and Brookhaven are working, glass electrolytes, SION Power on new coatings technology and both Berkeley and Argonne have collaborative efforts under way with several tasks [to develop] structures that would mitigate the issues with dendrite growth.

In terms of lithium sulfur efficiency and utilization of sulfur we have two programs that are under way. A dual phase electrolyte at ORNL on the carbons and research projects focused on the bifunctional catalyst or oxygen electrode.

All of these projects are contained in our annual report and so you can get much more detail on any one project from our website in the discharge view technologies program.

One thing we haven't done a lot of in the past is processing research and development. We've done some pieces of that in our battery development efforts but we're making a more concentrated effort to develop new processing techniques and lower cost processing techniques for lithium ion batteries. Here you see a typical schematic of the [lithium battery manufacturing process] – I realized that it is hard to read, but this is a typical schematic of the fabrication of lithium ion cells, [including material mixing, electrode coating, electrode] slitting, [cell assembly,] and then formation and sorting and inspection. So we think there are quite a few areas that lend themselves to advances in this space. Particularly in the anode [and cathode] mixing step, [such as the development of] low cost materials processing and production capabilities, substitutes for the NMP solvent, which is a significant cost to all of these manufacturing processes: Developing; dry processing; and fast curing binders. In terms of the coating and drying process, [we need to develop] high speed deposition techniques, UV, microwave and infrared drying and curing, high packing densities of the electrodes are very important, and in situ separator coatings could significantly reduce the cost of processing technologies. Breakthroughs are also needed in the winding and the fabrication and the assembly of the cell. Very high speed high precision winding and stacking equipment, high throughput [electrolyte filling, and] low cost [electrolyte] material production.

And toward the end of this process the formation step is used to assure the performance and life and safety of the cells. But typically in any of these batteries systems it's a two to three-week process, which requires a major capital expense and major expense overall in the cell manufacturing. So we need breakthroughs in this area. One of the key things would be to be able to form the SEI layer during material mixing or electrode processing. That's what most of the formation step is about is forming a good SEI layer which stabilizes the system, enables it for the cycle life that we need in the calendar life and also has some safety implications.

So we have in our last funding opportunity announcements began to fund work in this area. I'll leave it to you to read through those because I'm shortly running out of time.

Let me move our attention to ARPA-E. In 2009 ARPA-E received some recovery act funds and one of the areas they invested in was energy storage for not only transportation but the stationary applications and the transportation area we worked with ARPA-E to develop the performance targets with Dave Danielson and his staff and to ensure that number one the performance targets were transformational enough for technologies to be challenged. [Here you see the ARPA E] performance targets [for electric vehicle batteries]. I'm sure most of you know them already.

In the 2009-2010 timeframe 14 contracts were awarded through ARPA-E. You see them listed here starting at the upper right-hand corner. Four projects in the metal air system both lithium and zinc air. They also awarded a project to SION power on lithium sulfur systems. They awarded a project [for coating] processing technology to Applied Materials. [ARPA E awarded] two projects in the ultra capacitor area, two in solid state batteries, one in magnesium ion and three in lithium ion systems. These are “Out of the box” ideas. Please, \ use the resources at the ARPA-E website to [research] the background and the progress in each area. The vehicle technologies program is [ready to pick these technologies up as they mature] and carry them the rest of the way. The hope is that these technologies [can] go from the [transformational] all the way to developing a commercial-ready battery. But either way it would be a big success.

So let me finish. I think we've got a pretty good track record at the Department in terms of energy storage areas, both the nickel metal hydride batteries and lithium ion. We have intellectual property that went into that both for the Toyota systems and the battery systems that were marketed. In terms of the lithium ion battery, we worked with Johnson Controls to develop the battery for the BMW hybrid systems and we have had a lot of success there.. It wasn't just one contract, it was [several contracts for] development work that cut across each TRL level, university and laboratory and industry efforts to bring those technologies to marketability. And we would see the same thing taking place with future technologies. It's going to take many levels of research to develop technologies that are market ready. We think we have a clear pathway to meeting our 2015 goals, and on our way to the 2020 goals as well. Our program is closely coordinated with ARPA-E and also the Office of Science. With that, I'm finished.

>>BEN BROWN: Thank you very much, Dave. So we'd like to welcome ARPA-E's Mark Johnson to the program. He's the ARPA-E Program Director for the Dispatchable Storage Program which is focused on disruptive grid level energy storage solutions. Mark?

MARK JOHNSON: Thank you very much. I really appreciate this. Welcome everybody. My name is Mark Johnson with the Advance Research Projects for Energy. I'm presenting today, talking about the ARPA-E programs in grid level storage or stationary storage and also the programs that are in the Office of Electricity that are

managed by Imre Guyk, who is the program manager there. and sort of how as fundamental breakthroughs in basic science wind up rolling into impact across things on the grid, how do those technologies actually make it out to the grid and what are some of the problems they solve, and what are some of the programs that are ongoing on the higher TRL level that if successful in some of the basic research work, it would wind up having impact across those boundaries.

So I'm giving you a quick overview of what stationary energy storage needs are and then give you an idea of what are some of the programs and projects we're running within ARPA-E and within the Office of Electricity as well in storage programs to give a flavor for where the impact winds up happening. So I think many of you are probably familiar with this sort of graph. ARPA-E winds up sitting in the valley of death between Office of Science and the applied offices and specifically the applied office that deals with things on the grid is the Office of Electricity, because storage does a lot in terms of how you wind up maintaining a higher reliability and keeping the power grid running in an effective manner. In the applied offices the other area that we're having more and more interaction is with a lot of the renewable generation. So in EERE where you have the wind and solar program, interacting with them in terms of the applications.

So let's start with what the grid is first of all, there are three grids in the United States, often people don't recognize that. You have the eastern interconnect, western interconnect and Texas. The three power grids that wind up interconnecting the system. If you think about this, this is actually the biggest machine in the world. It's simultaneously synchronized in those machines to give you high reliability and up time. If you think about the requirement for reliability, think about how often during the day your cell phone doesn't work. Would you put up with that with your lights? No. So the reliability has to be very, very high. And you wind up having interconnection between the number of generation sources and the locations where it winds up being consumed. One of interesting things is there's essentially no warehousing on the power grid. You have about just around five hundred gigawatts of capacity on a daily basis providing that grid such that essentially it's generating electricity almost instantaneously from when it's consumed so you have availability on the demand side constantly being adapted on the supply side. What storage does is it's actually becoming that warehouse. So it fundamentally winds up separating in both space and time load and generation. That's a big transformation to make that happen.

So who are some of the people that wind up talking about this. Secretary Chu talking about efficient large scale energy storage, “it will be difficult for us to get renewables beyond about 20 to 30 percent of our electricity”. So one or two percent electricity, you wind up having your generation capacity, you wind up having adjustment in the existing power system is able to accommodate that. Once you get large renewable integration then you start having a perturbation of that system that you need a damper to adjust that out. Another thing is anything that goes on the grid has to have rules for how [what is attached] winds up being interconnected. The people who set the rules are FERC, Chairman Wallinghoff is looking at how storage is practiced on the grid. So active that in fact yesterday there was a ruling that significantly affected how you went about

monetizing storage on the grid called pay for performance ruling. That's the other factor that winds up feeding into the third area is you have something called independent system operators. These are the people that operate the transmission grid, connect between the different generation companies. And the largest one in North America is PJM that covers the power grid from New Jersey to Chicago, [which is led by Terry Boston].

And to show you how sold into storage Terry Boston is - his actual Ph.D. thesis was studying pumped hydro facilities in Tennessee. So storage is something electric grid people really love. The problem is how do you get it cost effective and reliable enough so it can be adopted everywhere.

People have been storing energy for millennia by pumping water uphill and letting it run down[hill]. So what we need is – how do you get something that's effective and cost effective but have it deployable anywhere where you don't have a mountain [where] you can pump water up? So you can put it into small scale installations in urban environments. That's the system level challenge. If you look at where you can wind up using storage, there are – actually I've [listed] here 12 specific applications. If you want to look in more detail, both EPRI and Sandia National Labs have done very detailed studies where it breaks out 12 and 25 unique applications of subsets. And these applications depend on whether that storage is located close to where the generation is, or where the load is. Is this an asset that's soft, like a generation asset or something that winds up helping people consume energy more effectively? The differentiation is in terms of the power level, and this is just a small vernacular difference – the word capacity – people when you start looking at batteries in regard to this, capacity on the grid is actually a power metric. Capacity with batteries obviously is an energy metric. So just to know that's how the vernacular works. Duration, that's the energy. Ramp rate; how fast does it change from one power level to another power level? And then cycle life. Because assets that wind up being put on the grid to be adopted, you need to be able to put it up there and not have anyone even look at it for five years and have some sort of expectation of it. There's a huge need for R&D around all of these issues. Ramp rate is one that's really important also if you're starting to look t electrochemical systems just to lead into this, is if you look at some of the applications. So take lithium price, people will look and say “I'm going to make an energy storage system that deals with power in the peak in the average and it's a four-hour peak so I need a four-hour battery.” Immediately electrochemical people go “I need a battery that does C/4.” What you're missing on this when you do that is that it's not a smooth power level for four hours. It's very, very spiky. So you may have periods that are one C and other periods that are C/6 during that time frame. You want to make sure that you're not creating some sort of degradation mechanism or at least have some understanding of what happens when the power is spiky during that time frame. So understanding the applications and building that research around what you're trying to solve is really, really important.

So in the ARPA-E program we specifically looked at what's called ramping. Ramping deals with the problem of actually having over wide control areas substantial rapid

changes in power. So you look at solar, that's not a solar for one photovoltaic array, this is averaged over about a hundred kilometer area where you wind up having meteorological events like 50000-foot pressure changes where it gets hazy over large areas in a five-minute period. You drop out a lot of solar in that area. You have the same thing when weather fronts come across. This is data out of the Pacific Northwest. If you look at the magnitude of those changes you're talking about gigawatt scale changes in the wind there, like having a nuclear power plant show up on your power grid that you weren't expecting. That's a huge storage challenge to wind up meeting.

So, first of all, before we define storage as the problem we wind up saying this is a grid problem, not a storage problem. What are the other ways these problems can be solved?

Well, you can average over larger areas, this is called increasing the balancing authority. But if you look at where that data for the wind was, that was actually over -- that white area on the map is most of Idaho, Oregon and Washington that's one balancing authority run together. You can build increased transmission capacity. That's the storage-less solution -- build transmission wires everywhere. Good luck getting that permitted. Improving situational awareness, having better real time knowledge about weather conditions -- huge, huge needs for those on the grid.

But even with all those resources there's a need for new storage technologies. Just to give you an idea about balancing authority in the Pacific Northwest, they right now have about a third of their demand satisfied with renewable wind. They want to go to 150 percent of their demand with renewable wind. Why would anyone -- because they have a state just to the south of them that said we want a bunch of renewable power. Much of this is actually an economic development plan. We need to be able to have that resource of that generation and be able to transmit it without losing reliability of the power for your local customers. That's where the storage really can become a value.

Giving you an idea of magnitude of the problem, this is an average week from earlier this year, the line on the left, the green line is the actual production level of the wind and you can see that goes between zero and three gigawatts. That's three nuclear power plants worth of wind power. And the line on the right is essentially the minute by minute five-minute periods throughout the week what they call the set point, which is essentially the prediction of how much wind is going to be generated at that time frame. The difference [is] that, they have to wind up making up some sort of balancing reserve that will be the storage. The way they do it now is they adjust the hydro power capacity that they have and they're allowed a band where they can make those adjustments you wind up seeing that balancing reserve being deployed and you'll find 15-minute periods where you have 500 megawatts of power spike up and spike down. That gives you a sense idea of how spiky, how fast it changes, how quickly it winds up ramping, and [what is] the data we need for storage technologies.

The other point is making this competitive with the existing technology, which is pumped hydro. Depends on whether it's a legacy facility or a new facility that's being built but

essentially it's somewhere in the range of $100 of kilowatt hour in overnight capital cost, the net present value of the entire system. It's about the price point where you'll have storage wind up being competitive with competing technologies.

The primary technology storage is competing with is building natural gas plants right now. It is not building new transmission lines. Cheap natural gas changes a lot of things on the power grid. So again, if you take $100 a kilowatt hour assume five thousand cycles for that, you're talking about $0.05 per charge discharge cycle that winds up $0.05 per kilowatt hour. That's essentially the interest rate you would be paying on the electricity you buy to what I wind up reselling. So you can solve this with a number of approaches. This is the ARPA-E project we did where we made it technology agnostic. You have electrochemical and touch on a couple of electromechanical and electromagnetic approaches that are out there, but it's really driving towards low cost high reliability highly scalable storage technologies.

You can look at this. This is the profile of all of the projects. Start out with flow batteries. You think about a flow battery, this is equivalent to a fuel cell, an electrochemical fuel cell except the analytes and catholytes are liquids, because then you can get a much higher density of the electroactive chemicals across the membrane. One of the challenges that you wind up having with the flow battery is actually about 80 percent of the cost is in that power module and then you have electrodes on either side and typical chemicals people would use something like oxidation states of [vanadium where you go from plus two to plus three on one side, plus four to plus five on the other side of the membrane. How do you wind up driving down the cost of that membrane? One of the projects we have is focusing in on that technology specifically and it comes down to basically increasing the current density of that membrane. So state-of-the-art technology for the best work being done in the U.S. and in China [is] on the order of 150 to 200 milli-amps per square centimeter. United Technologies is leading this program [in ARPA-E and is pushing the current density to] 1 to 1.2 amps per square centimeter. For the same cost you wind up driving that power capacity up. The challenges are you have a lot of electrochemical reactivity at the surface, understanding how that chemistry works, how that builds into a system level construct as well.

This is an interesting project where if you're looking at low cost material, it's an iron air battery. A metal air battery where you wind up using iron, controlling the oxidation state into the plus two state. What you want to do is not have it go into the plus three state. If you're using this for a vehicle, no one would look at iron air batteries because the voltage difference in electrochemical potential isn't that high. However, the electrochemical potential per dollar, iron is the most widely used by weight industrial material and it's dirt cheap and available everywhere and air is free. This is a really interesting project. A lot of science on how you wind up suppressing side reactions and controlling and minimizing hydrogen production on the iron electrodes as well.

Flow battery technology where it's reinventing lead acid batteries. One of the challenges with that is sulfidation, which is if you use the sulfuric acid and wind up going

too low of depth of discharge, you wind up forming sulfides on each plate. So first thing you do is you switch that out from sulfuric acid to methylsulfonic acid and wind up using porous electrodes where you go lead to lead oxide through those porous electrodes. The interesting thing here is when you're charging the battery; actually both electrodes are putting lead ions in the solution and discharge you're pulling it back out. You can actually increase the total capacity of the system by pumping the electrolyte out so as you're pumping ions into the solution you have a much larger volume of the solution. The challenge on this is controlling the reaction particularly on the lead oxide interface with the crystallography with that lead oxide on those graphite electrodes. This is a UC San Diego working with general atomics.

There are some competing technologies out there as well, just keeping aware of it, some of the breakthroughs that have gone on this, the SMES technology which is essentially is taking a super conductor, storing energy in magnetic fields, things like advances in flux pinning where we are at an inflection point where this technology starts making sense in terms of potential economic approach in energy storage as well -- particularly for more short duration storage problems. And the same thing with fly wheels where you have electromechanical storage. In this case the challenge on it is that essentially what limits the amount of energy density you can put in a mechanical device is the rupture strength of the materials' outside perimeter. You're putting it in kinetic energy on that. It's an interesting composite problem where you build basically a magnetically levitating spinning body except you have to do that at cost. So essentially you want something that has mechanical properties of the strongest carbon nanotubes but have the cost structure ever something like fiberglass. How do you accomplish those goals?

So that's just a high level overview of some of the projects at ARPA-E and the Office of Electricity stationary storage program really is sort of a bridge the gap from some basic science work all the way up through deployment, done that for a number of years. Everything from working for SBIR projects, doing some university projects, as well as funding research directly at PNNL and Oak Ridge, which are the main labs that have done work on this over the years.

So to give you an idea where the strategy is behind this, there were a series of workshops held last summer, stakeholder workshops, TMS published this and participated in this. But we had ARPA-E, EERE, the Offices of Science participated as well and OE and in the first couple days we brought in people from utilities and said, "Objective: Define what your storage challenges are." Let's get that use driven need requirements put together and really engage the community on that.

Then the second couple of days brought in people from the scientific community and said "what can storage do?" and try and meet these across the boundaries and that wound up actually feeding into the comprehensive storage plan on that.

The other part was stationary storage. This group of people between EERE, OE, ARPA-E and Office of Science really talked together to say how can we wind up making

a community so that as new breakthroughs in science are coming out, we're not overlapping but we're not leaving gaps all the way from basic research through advanced research, development, then demonstration and supporting deployment projects.

So some of the projects that are supported: for instance, at PNNL on developing advanced redox chemistries or redox flow batteries and doing research in those areas. There's a planar sodium metal halide battery technology out there, essentially a solid state electrolyte where you wind up having sodium and metal halides across the other side of that. This is working with the ARPA-E project as well. Interesting chemistry coming out of a company called Aquion that's spun out of Carnegie Mellon where they use a sodium ion battery plus potentially very, very safe chemistry on this. When looking at things on the grid you are concerned about weight and size to some degree, but it's not as critical as in the transportation application. Cost is the big driver on that. So sodium ion battery is the approach that's being supported on that. As well as looking at some of the lithium ion battery chemistries and how they roll into storage. At Sandia they do a number of research and development projects but also wind up getting involved in some of the assessment, looking at how does the grid work on an actually computational modeling basis, fitting that back into really well developed techno-economic models so you can then plug in your advancement in the science and technology and how does that wind up impacting the cost structure as it winds up getting towards the grid -- and then supporting some SBIR projects as well. A third area that winds up getting involved in at Sandia is some of the battery management systems, how you wind up developing the power electronics that wind up applying for battery management systems.

The Office of Electricity's funding is on the order of $200 million a year. The stimulus program really came along especially with the smart grid stimulus programs where multi billion dollars injection of capital into it, and storage was one area. We had an opportunity to do a lot of good demonstrations out there in development projects. They worked very hard to make sure that they wound up leveraging that money. So they had $185 million in storage project demonstrations of which they wound up having about a four times cost share on top of that. So really engaging communities across pretty well, looking at large battery systems, compressed air, fly wheels and distributed energy storage projects and then some basic technology development as well.

So to give you an idea of some of the projects, the company Primus power in the Bay Area, they've got what's called a flow battery project. This was their first generation product ARPA-E is working with them as well to develop their next generation product which is the -- which has a change in some of the electrode structures. But in this case what they're doing is they're putting out some of the agricultural areas in the Central California where they need to keep the high power reliability to support irrigation systems on the hottest days of the summer. Those are days when electricity is the most expensive in California. So they really need to do is have some additional generation capacity on site right within the Modesto water district. So doubling a generator is an expensive proposition. If they can wind up putting storage in as well

they can substantially reduce the size of the generator and achieve the same goal. And essentially this is a common theme for a lot of stationary storage. They wind up taking these containers inside of here and build up a series of -- you can see a series of these canisters here that are sealed flow battery units that wind up inside the container in here and the containers get put out as modules as a storage array for those. You see the same approach with lithium ion batteries and this sort of common way to wind up building a modular scalable approach to grid level energy storage.

Doing a similar sort of approach here, this is building up [those] modular approaches, this is near a wind farm about an hour and a half north of Los Angeles. How you wind up smoothing out the power for the wind feeding into the Los Angeles area. This is the first demonstration project that's completed. You can see this was commissioned in the last month. This is New Mexico power where they have a solar farm that has storage connected in with that as well. Then to another big area is what's called community energy storage. This is AEP in Columbus Ohio, and in that case what they did was put small storage units out in communities near where you wind up having a transaction former. This winds up making it so you size the transformer for the largest peak power of the day essentially, but with a little bit of battery there you can wind up going beyond that limit, you take the load off the transformer so it's winding up storing the power closer to the customer. What's neat about community energy storage is this is a great opportunity for combination between electrochemical storage used for transportation and that's used for the grid. [At] the end of life, where you no longer have the battery capacity to support a vehicle, it may have 60, 70 percent of its overall capacity still remaining. And so it's a low cost effective use of [so-called “end-of-life” batteries] where you essentially put them in a pack with some power controllers and wind up reusing them on the power grid as well.

This is a frequency regulation plant – [this] is a flywheel system so it provides a lot of instantaneous power. These are some flywheel units and this is a plant being built in Pennsylvania right now. And PG&E is doing a compressed gas field. This is just outside of Bakersfield where you wind up using depleted gas wells essentially and pressuring the gas to bring it back up. That's a competing technology.

Some of the new technology projects that OE is supporting are looking at the sodium ion battery, Amber Kinetics is developing a flywheel technology, Enervault is developing an iron chromium redox battery. This is out in the agricultural areas. This is in fact supporting some of the, I believe, walnut or pecan farming out in Turlock, California. Seeo is looking at some advanced polymer electrolytes and then Sustain X is look at advanced compressed air energy storage technology.

The main message is to say that we wind up working very closely between BES, ARPA-E and OE to bring things together. What highlights that is what's going on now in San Diego is the ESAT conference. They were in the area of grid storage, this was sort of five years ago you get to a conference and there were 50 people in the room. There were four hundred people there this year.

I think in summary, just to give you a high level of where I see what some of the needs are, there's a wide range of science and technology needs and opportunity. But the focus on low cost highly cycleable approaches to electrochemical storage is one of things that is really [a] science and technology gap relative to stationary storage out of storage technologies and having leveraged approaches are really important. So I think things like battery reuse and things like that are really important as well.

With that, thank you very much.

>> BEN BROWN: Thank you very much Mark. I have one quick announcement before we head to our break. Those of you planning to offer oral comments in this afternoon's sessions - we're not going to sit there with a stopwatch and time you but we would like to have a fair meeting of the time. So, we're thinking ballpark if you can keep your comments to about three minutes, we will be watching the clock and we'll have a giant cane ready to pull you away. Our panelists will be sticking around to hear the afternoon comments sessions. They will not be responding to questions. All of the comments will be reviewed and considered very carefully, and so with that, we will reconvene at 10:45.

(Break)

>> PATRICK GLYNN: If everybody could take their seats, we'll get started with the next segment.

Well, welcome back. I'm Patrick Glynn, Senior Policy Advisor in the Office of Science and I have the pleasure this morning of introducing to you two of my Office of Science colleagues. The first speaker in this segment is John Vetrano, and John is a program manager for technology coordination in our Office of Basic Energy Sciences and he also works as a program manager as part of the DOE Energy Frontier Research Centers management team.

John?

>> JOHN VETRANO: Thank you, Patrick. And welcome, everybody, to the second half of the morning session. So I'm going to talk about some of the fundamental electrochemical energy storage research that we sponsor within the office of Basic Energy Sciences.

And you've heard today already from people over in the applied technology offices such as EERE, things from OE and also ARPA-E. Today I'm going to concentrate more on what we're doing in the Office of Science.

And so this is sort of the structure for those of you who are not as familiar with how DOE is laid out. And at BES we have a different mission than in the technology offices. So what we're trying to look at is fundamental research and we want to understand, predict and control matter and energy at various levels down to the very fundamentals. We also want to make sure we provide the foundations for new energy technologies that are from the applied technology offices that we just saw and provide the underpinning research and science that can feed into those offices.

And as well we plan construct and operate a number of user facilities. And those are very important for being able to do some of this research. This is just a map showing some of the Basic Energy Science user facilities. We see a number of them in blue the light sources on the West coast and East Coast there and also here in Chicago, the purple ones are the nano centers as well, and then the red are the neutron scattering facilities and the green are the electron beam centers. [Some] of the highlights I'll give at the end of the presentation stem, a lot of them, from work that were performed at these user facilities.

So one of the things we've been talking a lot about today is this sort of continuum of research and development going from discovery research on the left, which is the more fundamental, over to technology maturation and deployment, and then across DOE how we work that. So you see on the left this is where Office of Science sponsors research and on the right is more what ARPA-E and the applied programs, that's where they do that. And they have different goals where in science we're looking at new knowledge and understanding, focusing on phenomena and trying to generate knowledge that's our metric so publications, for example, where for the technology offices it is more practical targets. They're looking at performance and they have milestones for technical achievements.

So I think that continuum is important for DOE and how we coordinate that is important. And there's a number of ways that we do that. One of them comes across naturally from some of the same people, who have been discussed earlier, who have done research with ARPA-E or OE or EERE are also funded by the Office of Science. They have to delineate the work that they do so that the work they're doing for each of those offices has a distinct goal and stays separate. But it allows that connection to bring fundamental science towards technology and also showing interesting problems that may crop up or phenomena that you get in applied programs and allow you to study them in Science.

So the way we do that at Basic Energy Sciences is [through] research. We have sort of three funding modalities. One is the core research, and that's we have many of those projects. That's our standard programs, at laboratories, universities, and industry. These are generally single investigator or small group projects looking to pursue their scientific research interests. And then we also started 46 Energy Frontier Research Centers. These are larger, two to five million dollars a year, they were established in 2009 focusing on fundamental research related to energy. Then as we were talking

about earlier, the energy innovation hubs and there're three existing across DOE. These are larger and with a focus of integrating across basic and applied research.

Dr. Dehmer mentioned this morning about this series of workshops that we held, both here in the science for the grand challenge science for discovery, a number of the basic research needs workshops focused on energy, and then a number also for the user facilities. In particular I wanted to mention two, one is the basic research needs for electrical energy storage that was held in 2007, and a number of people who are here participated in that workshop. And also in 2010 was a report called the “SciTech” report [full title: Science for Energy Technology: Strengthening the Link between Basic Research and Industry] and that involved more people from industry in looking at the applied technological challenges there. So that also had a component in there, one of the panels was on electrical energy storage.

So those of course are available, all of these are available online.

This was the basic research needs for electrical energy storage [report]. This is sort of the summary slide. John Goodenough from UT Austin was the chair. Hector Abruna for Cornell and Michelle Buchanan from ORNL were the co-chairs. We had three panels: chemical storage science, capacitor storage science and cross cutting. We also had a number of plenary speakers [including] the science and technology aspects, and here's the charge to identify basic research needs and research needs with a focus on new and emerging science challenges with potential for significant long term advancements.

So if you haven't seen this report, I think it turned out to be a very valuable report. Within these basic research needs workshops, what we would do is develop a set of priority research directions. And those are the things that say well, where do we need to focus our fundamental science? And this is a list of them here. I think they should come as no surprise to the people here that these exist and that these are the things; novel designs and strategies for chemical energy storage, interfaces and interphases, and so forth. And also it's important to note there's a number of what we call cross cutting science directions, things that are going to impact across the range of different technologies and types of energy storage, and that's advances in characterization, nano structuring in materials, innovation in electrolytes and [theory, modeling and simulation.]. If you look at the panel results and priority research directions from the SciTech report with more industrial focus you'll see those are largely echoed here. There's a good overlap and gives us some confidence we're moving in the right direction both scientifically and towards technologies.

So this was the way to sort of boil that down from the basic research needs. And that would to be think about it in three ways, this sort of research framework. How do we approach the theoretical energy density, how do we increase the rate of energy utilization, and can we create a system that's as close to perfectly reversible as possible? So each of these has with it a range of ideas of what our needs are, what do we need to do to be able to get there?

Now that we've set the stage about what our priority research directions are, what our needs are, how do we do that. This is something that David Howell showed earlier, the budget cross DOE. The basic energy sciences investment in electrical energy storage is around $20 million per year. So one of the ways I mentioned was the core research program. We also started a number of these Energy Frontier Research Centers where these again are a little bit larger projects engage being the talents of the nation's researcher for the -- researches for the broad energy sciences, accelerate this discovery. So we wanted each one to have a range of sort of science -- fundamental science towards use inspired basic research. And understanding how this will work towards clean energy. So 46 of these were awarded in fiscal year 2009 – a total of 777 million dollars over five years. And they represent a broad cross-section of research in the United States of 115 participating institutions in 35 states and Washington, D.C.

What they need to do, what we asked them, the EFRCs, to do is [to] pursue collaborative basic research topics. So we're looking at energy challenges, more use-inspired, basic research as well as very fundamental science grand challenges in each of them. Of these 46, six have a primary focus on both the fundamental and use-inspired research related to electrical energy storage and that cross cuts the technologies for vehicles as well as for the grid, and several are also performing research bits relevant towards that but it may not be their primary focus.

If you look across the portfolio from basic energy sciences the EFRC and the core programs you see a number of topics that you can kind of group a few ways. And this is just sort of a list of [how] we would sort our current portfolio, what it covers, and what you'll see in this. I'm not going to read them all, but you'll note that there's a pretty good connection with the priority research directions as well. And that's as it should be because this is what the community is saying are the important parts to work on.

So I wanted today to give just a few scientific highlights from recent Basic Energy Sciences-sponsored research in this area just to give a flavor for what we mean and what we do. Some of you may have seen some of these slides before. But bear with me as I go through them.

One was from Dan Morris who [used bio-inspired catalysis to create a tin-graphite anode]. They used a low temperature process to create this mixture here. You can see you've got a graphite matrix and very small 200 to 500-nanometer tin nano particles are [formed] in situ in the graphite. This is the bright dot, the tin, and they did a variety of analyses with X-rays to confirm where things are. What they found is that, because tin expands upon lithiation the graphite kind of allowed the tin to breathe. You could get good capacity at high charging rates. So this was something that is not a battery or a battery system but it's trying to understand how you could potentially make some anodes in this way especially using the low temperature processes.

This is another one that a number of people have seen because we've talked about this a lot from our Energy Frontier Research Center. This was led by Jian Yu Huang at

[Sandia National Laboratory] (SNL), and this was in one of the Energy Frontier Research Centers led by Gary Rubloff at [the University of Maryland] (UMD). And the work was actually done in the nano center at Sandia National Lab. They basically made a battery in a microscope and took -- suspended an ionic liquid between a cathode and these tin oxide nano wires and ran a potential across it while they watched in the electron microscope. So you start with a straight tin oxide wire and as it is lithiated, you see this sort of curved band. If you watch it, it looks like it’s alive, and that's because, again, of these large stresses from the lithiation. What they could see was that here you have the crystal and tin oxide up here, lithium is moving this way in the area where it's starting to lithiate you get this dislocation cloud pushed along in front and then here the material is amorphous, and this actually moves fairly quickly.

So again, this is not something where you're not going to make a battery just like this but the idea is to understand the fundamentals of what's going on in terms of this lithiation and can you understand how to alleviate differences in stress in some of these materials that swell as lithium moves in and out.

Here's the last one. This was from Nina Balke of Oak Ridge National Laboratory, also at an Energy Frontier Research Center. This work was also done in a nano science center. These are available to users to go and utilize in a similar fashion. So what they did here was they made a solid state battery with a lithium cobalt oxide cathode, LiPON film for the electrolyte and amorphous silicon over the top and used the strain from the lithium moving up through and into the silicon, they could measure that strain by biasing the tip on a AFM. So they would scan across as they did charging and discharge. And if you follow this, as you increase charging you have this sort of red is the higher strains where the lithium is and it -- if you charge it up, this shows up first at these features in the silicon that are topographic features and then it broadens in between the grains. You see the resolution here is really good. So, again, it's not a battery that you're going to make but it's a way to say we can make these measurements and get a better understanding of how lithium moves in these materials as you go through charging and discharging.

And again I wanted to point out that we have these user facilities that I showed you the map of earlier on, and people are using these and developing techniques to perform research that's relevant to electrical energy storage. And this is an X-ray beam at Brookhaven (National Laboratory) where they're making measurements on a battery to look at some of the changes. Here's some work from (Lawrence) Berkeley (National Laboratory) where they're measuring the electronic states in this new polymer they've developed. So there's these ways you can make these measurements. Also, and this is just a schematic, this is the Vulcan end station at Spallation Neutron Source at Oak Ridge National Laboratory. These are steps. So this is a room. There is a lot of room to work in there. It's not little, like the [sample volume] electron microscopists [are used to where] you have to fit very, very tiny samples. They've been using this to look at the development of strain in these materials as the battery cycles back and forth.

There're also additional synthesis and characterization capabilities at the nano science centers and also the electron microscopy centers as we just discussed.

Now I wanted to put this slide back up. And this -- I'm not going to read all the way through it, but this is now this R&D continuum that's more specific so electrical energy storing where we go in and say what are the things related to energy storage that BES is doing in the discovery research and use inspired research and what are the things that ARPA-E and EERE and OE are doing more specifically. And then looking where each of these sort of span these different continuum here, the EFRCs, user facilities, development and test facilities demonstrations ARPA-E and then the proposed battery and energy storage hub.

The last thing I wanted to show was a couple of examples because it's easy to talk about coordination between research offices or how we translate science to discovery, but it's good to be able to show people examples where we really worked to do that and here's a couple of examples in the battery area. This was fundamental research that BES sponsored at Argonne National Laboratory where they discovered this new composite structures for high capacity cathodes. What that's led to is more applied [research]. Well, this material is works really good. They used the advanced photon source and did some in-situ studies to understand how this works, and then in the more applied end they had funding to then create these high energy lithium ion cells and doubled cathode capacity and advanced stability. That came out of more the technology office funding and then that was picked up in the commercial sector and developed into products that we use today.

That's one example. Here's another many of you may know as well. This was fundamental science that BES sponsored at MIT with Professor Yet-Ming Chiang. Again, in the '90s. In understanding how these some of these lithium ion phosphate model materials worked, they discovered by nano structuring and doping they could increase the conductivity by a large amount. From a fundamental science standpoint, that's very interesting. They then created a company and got some Small Business Innovative Research funding as well as funding from EERE and developed more of a cell and something that was more commercially relevant and then that was then -- they used that to form a company, and they now sell these materials in products that you probably use. That's just one way, and I think it's important that we focused on that a number of times with these tech teams and trying to work with each other across the different offices so we have a good idea of what's going on, what each office's goals are and also that the people doing the research are aware of what else is going on and the impacts that their research may have.

So again this is just our website. There's more information about BES can be found there. So thank you very much.

>> Thank you very much, John. Linda Horton is Division Director for the Materials Sciences and Engineering Division in our Office of Basic Energy Sciences. And she's also working now as Interim Lead for the Energy Frontier Research Centers management team. Linda?

>> LINDA HORTON: Thank you, Patrick. And, thanks to all of you for coming today. I am very excited about what we're doing across the Department in batteries and energy storage research. And, I am pleased to be involved with the planning activities for the Batteries and Energy Storage Energy Innovation Hub which I'm going to speak about today.

Also part of this is R&D integration because the team that we have in the Department looking at batteries and energy storage research has been really critical in formulating possible directions and where we really need to be in planning for a potential hub in this area.

We all know that batteries are important. You've heard this multiple times today. This slide summarizes some of the administration's goals and why batteries are so important. Clearly, as you heard from Mark, the grid is important, maintaining the stability of the grid, introducing renewable energy to the grid all is going to require some advances in energy storage technologies to do that as effectively as possible.

And then, of course, is the goal to have enhanced use of all electric or plug-in hybrid vehicles, [with] the severe demands on energy storage that that will [need] to meet consumers' expectations, to meet our expectations, to do the most we can from an energy perspective, have things last a long time so we don't throw things away. And, generally, learning how to do this as best we can to help the energy sector - as well as the environment and the consumers.

We've seen this slide before, but it's so important I wanted to emphasize it again --that the planning for the energy storage R&D is really being coordinated across DOE between Basic Energy Sciences in the Office of Science with ARPA-E in planning each of their funding opportunity announcements and identifying the priority areas for their research. And then in the coordination on the vehicle side with David Howell's team and with Imre's team in the Office of Electricity in looking for, and identifying opportunities to work together to ensure that the scientific community and the industrial community are involved, engaged, and know from a communications sense what we're doing in these fields. This information is of course one of the things that this group is involved with in order to help plan for our community's activities and to plan for the proposed Hub. Some additional information, looking somewhat from the -- the top down, in recognition of the importance of coordination of the research in the last couple of years, we've formed some teams within the department to take what had been going on a more informal basis and truly formalizing the coordination of the batteries for vehicles as well as for the grid. This has a lot of top attention within the Department of Energy. We meet with the Under Secretary as well as the Under Secretary for Science

or their representatives on a frequent basis to make sure that we are all talking, communicating, and planning appropriately.

In the quadrennial technology review for which the report was just published, again, there was engagement across the Department in getting community input for those reports. And then internationally - energy storage is a really international game. There is research going on in many countries. We've had a focus recently with the European Union on looking at what the opportunities were for coordination of our research with that in Europe for energy storage, in particular for the grid, and that was jointly organized and had participation, again, across DOE.

And, very importantly – [coordination has been ongoing] in planning for the proposed Energy Innovation Hub. I guess I can't say that enough. That has been a really key driver in the past several months to make sure that we are getting input from everyone and talking with both the community and across the Department to identify what the challenges are and really understand where the Hub needs to lie on top of the portfolios and the research that we are already supporting in the Department.

And then joint PI meetings. Part of the communication is to get the PIs to talk to each other. There are a few examples where we have some of the same individuals who are actually funded by multiple parts of the Department, but the majority of individuals are funded by a single part of the Department of Energy and we like to get people together to talk and share their advances. We've had participation in the EERE's annual merit reviews for the last couple of years. We've brought in PIs from the Energy Frontier Research Centers and other PIs to try to really communicate, communicate, communicate, to get people really talking with each other.

So it's a two-way communication. Our PIs understand what the industry needs, what the challenges are in some depth so they can see what the opportunities are for their science. But also importantly, we as scientists don't always know where our science might have an impact. So it's important that the scientists share what they're doing with this broader community, because sometimes the impact will not be in the area that was originally planned when the research was proposed. So it's a dynamic activity and something that has been really exciting to watch happen over the last several years.

Turning to the Energy Innovation Hubs and what are they? We have right now, of course, three funned Energy Innovation Hubs. These are multidisciplinary, multi-investigator, multi-institutional integrated research centers, each and every one of them.

These were modeled in the planning stages after centralized scientific management that were seen both in the biology centers for applications of bio mass and doing research for the bioenergy centers but also the Manhattan Project, the Lincoln Lab at MIT that developed radar and of course Bell Labs that developed the transistor. And in looking at some of these successes, they have this strong single roof, this single organization, this environment where top researchers are brought together from, in the case of the Hubs, across many disciplines - not just the traditional disciplines for doing research in

the field - to really try to overcome the critical barriers to advances that are needed for energy technologies.

The goal with the Hubs is to advance the U.S. global leadership and they have focused in areas that have exceptional potential to be game changing to reduce our dependence on imported and to reduce greenhouse gas emission. [These] have been really important and new modalities for energy research. And again, these cross the department. They were not singly located at any part of the Department, although with anything that's funded you have to have one group that's responsible for everyone working together. There is a Hub management team in the Department. We meet monthly and talk about how all the Hubs are progressing, the best practices, and truly learn from each other as to how to help these Hubs be successful in their individual technical areas.

The Hubs have a holistic approach for research. The goal is to integrate basic and applied research. I've mentioned interdisciplinary in terms of things like academic departments, physics, chemistry, but also in terms of science and engineering or in terms of basic science and industrial research. The goal is to be interdisciplinary in every sense of the word.

Each of them addresses some critical scientific, engineering, and technological challenges. As I said, these aren't necessarily unique. There are overlaps and opportunities where the interplay between science challenges and engineering challenges and the technology challenges are really where the advances can be made.

Each of the Hubs has a strong leadership group. They have management and systems that really plan how they're going to approach the engineering challenges. And they have to create a strong culture of collaboration among all the participants.

If you go on-line and look at the Hubs, you'll see that each of the Hubs that have been successful have a slightly different approach to this, but uniformly each and every one has a very strong management team that is -- that has vision and really understands how to get these different groups to work together productively. It's important that the Hubs have a robust ties to existing R&D activities. As I said, we don't want to have an activity that simply reinforces what's already going on within the community. We really want it to be a new activity to build upon what's being done and to have the communication mechanisms that show how the Hub's research is going to feed into the other scientific programs, other research programs, but also feed into industry and have industry feedback to the Hub itself.

The ultimate goal is to enable totally new technologies that overcome current technical limits and to develop any technology to the point through prototypes, through some initial experimentation or, in the case of some of the modeling-based ones, through the validation of the models. The risk is [low enough] that industries will be willing to deploy whatever the Hub innovations are. So it is a really challenging but wonderful modality to really advance research for the Nation.

As I said, there are three Energy Innovation Hubs currently. They were funded in fiscal year 2010. The Sunlight Hub is managed by the Office of Science that's located at Cal Tech and Berkeley lab. One on Energy Efficient Building Systems design that's run by -- through Energy Efficiency and Renewable Energy and that's led by Penn State University. And, Modeling and simulation for Nuclear Fuel Cycles and systems that's run by DOE's Nuclear Energy group and that's located at primarily, led by Oak Ridge National Laboratory. Each one of these has a world class multidisciplinary highly collaborative research team, and I encourage anyone that really wants to understand the hubs to go to the DOE website for the hubs and actually go to the individual websites for these organizations, the three existing hub, because it is -- great websites and it's truly a way to see how these hubs are being managed effectively in the early stages of their research.

It's important to have strong scientific leadership at the primary location of the hubs. We have to have a clear organization and management plan for achieving the hub goal and to infuse a culture of empowered central management for the hub itself. The management is really important. The high scientific profile as a team has been very important, and as I said, it's really been an exciting group to be involved with from the concept through the early implementation.

There are three additional hubs proposed in the FY12 budget request including one for batteries and energy storage.

The drivers for a hub level effort in electrical energy storage are summarized here. We believe that a large team multidisciplinary hub research environment would really link the fundamental science and engineering research to technology and production needs that are really necessary to have rapid and meaningful advances across the spectrum. What we believe is that the research that focuses on single technologies or smaller scientific efforts are critically important. You never know where the advances are going to happen. But what the hub can bring is a focus across the technologies to really enable not just current solutions or science advances but next generation battery technologies.

The scientific challenges go beyond what we're funding through the Energy Frontier Research Centers, again, the Energy Frontier Research Centers by their modality and their focus provide an important contribution to the overall community, but the hubs are envisioned to take those research contributions, take the contributions from all these various streams and really provide a coordination as well as focus on the research that will take us to the next level that will help us solve these problems so we can reach some of the goals outlined in David's and Mark's presentation.

Different energy storage technologies have very similar underlying scientific challenges, but, of course, the diversity of engineering and technology issues. We believe a hub will ensure communication across the research-to-technology spectrum and across different technology sectors. An advance that might be originally envisioned in the planning

stages to impact some transportation kinds of batteries may in essence have their biggest impact associated with the grid. So we're looking for this holistic approach that will enable the cross fertilization of ideas across the different technologies and across the different disciplines.

We believe a hub would strengthen the links from basic science all the way to industrial development. The hub would support fundamental science and energy research through the prototype demonstration of the hub's scientific advances.

And the hub should have, or would have, a robust tie to the scientific community, the engineering community, and the industrial groups that are doing research in this area.

So as problems emerge and challenges come up, the science might have a solution that, as I said, wasn't originally envisioned for that particular technology challenge, but the communication links will be there to help make these -- the communication happen to different sectors of the community.

The proposed hubs could provide the transformational game changing science and engineering research that's required for the next generation of electrochemical energy storage. So we don't -- the hub could serve as a focus for other DOE research activities and complement these, it should and could benefit from and provide benefit to everyone in the community doing research in this area.

And we believe the hub can foster new energy storage architectures and designs that begin perhaps with a clean sheet of paper and are based on the innovation and advances within the hub.

If you look at some of the key scientific and engineering challenges and having had the first three presentations today, none of these are going to be a surprise, or if you look at any of the reports or the road maps that are outlined on the websites for BES, Energy Efficiency, the Office of Electricity and ARPA-E, you will find supporting documentation for each of these challenges.

In terms of the efficiency and efficacy of structure and energy storage, there are many new approaches that if we combine theory and synthesis in determining the design and optimization of both materials‘ architectures, and then the systems’ architectures, perhaps we can have self-healing, self-regulating failure tolerance, impurity sequestration; all of the various mechanisms that can help extend the lifetime and the performance of batteries and energy storage approaches, but that can also be based on abundant materials and low cost manufacturing.

Charged transport and transfer are keys to any electrochemical technology. Getting a molecular level understanding of what's going on at the interfaces with electron transfer, what's going on in the electrolytes? Can we have electrolytes that have strong ionic solvation yet weak ionic interactions, high fluidity and controlled reactivity? Can we understand the mechanisms that will truly enable the next leap in the system? Are

there totally new battery architectures and systems that haven't been thought of that integrate materials and components everywhere from the nano scale all the way to macro scales that will truly advance systems performance, perhaps reaching the goals that were set by the tech team for transportation or the very difficult goals facing the grid.

Are there totally novel approaches to fabrication and processing. We want to reduce complexity, we want to reduce cost, and the only way we can see to really, again, enable not just incremental improvements or even transaction formational improvements but the leap to totally new systems, and these are tied to materials and chemical processing advances that need to be made.

And, of course, underlying all of this from a science perspective is understanding energy storage, chemistry, and physics at all time and length scales. This is a challenge in many fields, but in energy storage it's particularly complex. Some of the analytical tools are being developed as John outlined, but we need to push those even harder to monitor the changes in structures and compositions and interface and bulk phases with spatial resolution that goes from the atomistic scale to the mesoscopic scale and with temporal resolution not just down to seconds but up to real time so we can help predict battery life times and figure out how to extend those even further.

Multi-scale modeling and computational tools are needed to understand the complex physical and chemical processes that occur in electrochemical storage and from the molecular scale all the way up to the systems scale. So the proposed Batteries and Energy Storage Hub is envisioned to transform the grid and electrify transportation. It's proposed for this fiscal year and it's going to work to develop electrochemical energy storage systems that safely approach theoretical energy and power densities and have a high cycle life. And, again, have the potential for fundamentally new and economic manufacturing.

There are a lot of systematic system challenges associated with this. There [are] materials science challenges, there are needs for innovative engineering and really enhanced scientific knowledge across all the disciplines engaged in the electrochemical energy storage phenomena.

So the proposed hub would address key fundamental questions and electrochemical energy storage including “can we approach theoretical energy density?” If it you look at all of the current technologies, you are well aware that the practical energy density is far less than the theoretical density. Through understanding, can we attain much closer to the theoretical energy density for energy storage?

Can we safely increase the rate of energy utilization? Can we create a reversible system with minimal energy loss through the charge and discharge cycles? Can we have batteries that last a long time and don't degrade and enhance the cycle life? Can we limit the use of materials that are not earth abundant? There's been a lot of emphasis over the last couple years on critical materials and materials that are, do not

have the availability that we need if technologies are to expand and batteries fall into that category. So are there earth abundant approaches that can help us with the next generation of batteries and energy storage.

Can we develop totally new battery architectures for this next generation that are even better than the ones that we have today? Can we enable truly innovative approaches to manufacturing and packaging?

So the proposed hub would link fundamental science, technology, and end users. And our vision is that it will collaborate with the current portfolio in BES, the Energy Frontier Research Centers, OE, ARPA-E, EERE. So we would not duplicate what's currently going on, but we would enable this whole new level of research to really jump start us for the next generation of batteries and energy storage.

People ask me questions about the status of the hub. It is in the FY12 request at the $34 million level. This would have included one-time funding of $10 million for start-up needs. Of course, that was the request. What is going on right now, the House Energy and Water Development Appropriations subcommittee recommendation is for a $20 million for the Hub as is the recommendation for the Senate Energy and Water Development Appropriations subcommittee. So we have a $20 million recommendation from both the House and the Senate right now. However, of course, in a continuing resolution, any new starts right now require either an appropriation or approval of the Hub as a new start by Congress.

So that is where we stand right now. So we're waiting for approval or appropriation. This eye chart is on the web, and it will be in this presentation. This is the chart that compares the features of the various programs from the core BES research, the Energy Frontier Research Center, ARPA-E, the technology offices, the EERE and OE, and then the proposed Batteries and Energy Storage Innovation Hub. [Showing the comparison in] terms of the investigators and their institutions -- leading up to, of course, the large multidisciplinary, multi institutional team that's envisioned for the Hub. In terms of the disciplines in each award from the many for the Hub through to the few disciplines that are found in most of the core program awards as well as ARPA-E and the EERE and OE's awards. The time of the awards: the Hub is envisioned, as for the first three, as an initial five-year award. The Batteries and Energy Storage Hub will by managed the BES, and it will be managed in close coordination with EERE, ARPA-E and OE to make sure we maintain the delineation of the portfolios and again, ensure this communication of what's going on in the Hub research to the rest of the portfolio and keeping those PI groups working together. And then, of course, the motivation and research focus for each, are summarized in that last column. For the Hub it is to integrate fundamental research through potential commercialization of storage advances that are relevant to transportation and the electrical grid. The breadth and emphasis of the activities are obviously to be influenced through the application and proposal process, and the lead institution, as with all the existing Hubs, would provide a central location and a strong scientific leadership to develop a culture of empowered central research management.

And with that, the summary slide: Where could the Batteries and Energy Storage Hub take us? I believe it is really this vision for the next generation of batteries and energy storage, [that the Hub] can move the science and technology for electrochemical energy storage forward at a very fast pace to enable the transformational developments for reliable energy supply and for the enhancement of the use of electrical vehicles in transportation.

[The Hub] should provide a strong linkage between fundamental sciences, applied technology, and the end-use community and create long- and short-term innovations that would otherwise not be achieved. If you look at the Hub and envision it as having the research that moves along, we expect there will be research that will peel out, something will happen, there will be an innovation and it will be commercializable or it can impact something else, and really isn't in the mainstream of what the hub plan. We have this vision of the research developments coming out from the hub and impacting the broader field as time goes on. So we would not envision that a hub would [only have a single] deliverable at the five-year mark, but that it would deliver innovation[continuously] in a process that might not be predictable, but certainly can be planned for, [over the five-years and would be] enabled through really aggressive management of the research activities.

The Batteries and Energy Storage Hub should provide a research framework for scientific discovery and transformational technologies -- again, focused on next generation batteries, not current technologies.

Thank you.

PATRICK GLYNN>> Thank you, Linda. We're a little ahead of schedule so we'll have basically a full two hours for lunch. I'm told, and I hope it's accurate, that Katie has a list of local restaurants to help you choose a venue for your lunch and we also want to thank her who did a terrific job of organizing this meeting which is always a big heavy lift. And we want to thank you for being a part of the meeting and, we very, very much look forward to your comments this afternoon. We will reconvene here promptly at 1:30. Thank you.

(Lunch break)

BEN BROWN>> Welcome back, everyone. I hope everyone has had a fine lunch and is recharged. I’m just going to go over some basic ground rules for these rolling comment sessions this afternoon. As I mentioned before the break in the morning the DOE officials seated here will not respond to questions, they're in the absorption mode. So if you have a comment, please approach one of the microphones in the aisle. Please state your name and affiliation – that will help us very much in producing the transcript of the event. If you fail to do that we'll try and remind you.

Also, this is an important detail. As you make your comment, please provide

your business card, if you have one, to Katie Perine, who will be floating about. That will also help us make sure that you are properly cited in the transcript.

Again, we encourage you to be brief in your remarks, but of course we're here to receive your input so we want to hear your thoughts, we're very much looking forward to that. As I said I'm not going to strictly time you as you make your comments, but please try and keep your remarks to in the three minute range. We do reserve the right to drag you off stage.

With that, I'd like to start the session. If you're submitting questions online, if we happen to have a pause or lull in the live comments, we will read comments as appropriate, for those who are online.

So the question for this session is “What is the right balance between science and engineering research for the proposed Hub?” I know that's slightly different than the one that's listed in the agenda, but you're certainly welcome to comment on that balance in general. But we're certainly interested in hearing your views with respect to the proposed Hub.

The microphones are open.

GARY RUBLOFF >> Somebody has to start this, I think. But you should have somebody taller to do this. I'm Gary Rubloff, University of Maryland. When I read this question I was puzzled, because I wasn't sure at first that balance is the important word. As I thought about it, I think it is an important word. But I would suggest that a more important word is bridge, and the reason that I say that is that I spent two decades in the industry, where the issue was the transition halfway between science and ---

I think that's somewhat of what the hub is all about. And I think there were two things that we learned in successful transfer between science and technology. One of them is joint programs, when people collaborate from both sides of that boundary; hopefully not a boundary. And I can imagine in hubs that would be happening, because the science people from the EFRCs and the people from the technology side of companies, that's going to be working on this towards the same goals. So the closer they collaborate, the better.

And the other thing is that very often the successes, enhanced chances of success, are enhanced by people transfers. So people would be encouraged to go from the development that they've done in science, over to a technology area, and teach people what they've learned, and see what the realities of their application are. And it might be that one of the places to engage the EFRCs in this is many of the people in the EFRCs are scientists, yes, but a lot of them are really interested in technology, and their scope of work in the EFRC is not all that far into technology. So I could easily imagine that by the hubs supporting more applied research by those same people doing the science, there would be a synergy there that would be really hard to beat.

BEN BROWN >> Thank you, Gary. Thank you for breaking the ice, Gary. We need a second ice breaker.

PAUL MUTOLO >> I'm Paul Mutolo, Energy Material Center at Cornell. This is going to be like a procedural question, maybe more than a comment at this point, we

understand we can't ask direct questions about the presentations we heard this morning; however, is this intended to be a one way dialogue back, or are there intended to be a discussion here back and forth about points that we raise this afternoon? There were some questions about that during lunch. Thanks.

BEN BROWN >> I guess the parliamentarian will respond. So all comments submitted here are being recorded, obviously, and will be read, reviewed and considered by all the people involved in the battery and energy storage R&D programs across the Department. The sessions in the afternoon, yes, are essentially one way. The folks on the stage will not answer the questions pertaining to the subject matter. But are here to -- and very interested in hearing your perspective.

BILL ACKER >> Bill Acker from the New York State Battery and Energy Storage Technology consortium, New York BEST for short. With regard to the basic science versus engineering discussion that you're bringing up, I think if you step back and look at the funding that's occurred nationally, we've funded a great deal of research, we've funded demonstration projects, and we've funded a lot of manufacturing.

We -- for the hub itself, I think it's very important that there is a fundamental science basis and a strong push toward making sure you've got a critical mass to have the fundamental science basis, but that it addresses multiple problems. So there's a very large distinction between the engineering and the end product required for the transportation applications and the engineering and end product required for the greater entry storage basis.

So making sure that we have the ability to address both of those problems nationally are very, very important. And I worry that a single hub with the funding levels that we're talking about may not be enough to actually address both those questions together.

I also see a gap, once you go from the basic science and demonstration projects, to commercialization, that involve the testing of large-scale systems. So we have a need in this country for the grid energy storage to prove out that large-scale systems work, and have long lifetimes, and can be actually adopted in the rates base by utilities, and things like that.

So that may not be directly part of the hub and probably should not be directly part of the hub, but it should be a strong link, and something else may go on to be funded through a leveraged way down the road. Thank you.

BEN BROWN >> Thank you for that comment.

MIQUEL SALMERON >> I will make it short, I'll make a general comment, I'm Miquel Salmeron from LBNL.

So this is regarding the basic research component, the fundamental basic research component of the hub. To me it's hard to conceptualize a project like a hub that is going to be of finite duration, like I don't know how many years, 10 years, 5 years. How you reconcile that with how you do basic science? You know, basic science is something that you cannot put a limit, a temporal limit, like that you're going to solve this problem in five years. Well, you could do that if -- I would be very happy to see it.

But when you look at the history, the basic science has lived very well in core programs that have lasted for a sufficient number of years. A long-term discovery process that usually you don't even know the answers that you're going to have. Most of the times you don't know.

So anyway, I'm -- perhaps my comment would be that it would be good that somehow DOE is in a position to have the hub, this component basic science, you empower some either reinforcement of the core programs that is directing the basic science to a synergy storage, or expanding that part or directing the funding in that direction.

BEN BROWN >> Thank you for that.

PAUL MUTOLO > All right, this time I'll have a substantive comment instead of just a procedural one. Paul Mutolo, Energy Material Center at Cornell. So my role at Cornell, as a couple of you know, is in partnerships direction. And so I work for the EFRC there, and yet we see it as an important part of our mission to keep contact with industry partners that are working in the technology areas in which our center is based, which is fuel cells and electrical energy storage for batteries and supercapacitors. So programs that we have that are funded by industry, we keep those very distinct. And that's almost a separate topic of conversation, but relevant to this question I think the important exchange with industry that we get is in conversation with them, to keep track of what their long-term goals are for their product needs. And in that conversation, we oftentimes find that the specifications that they're looking at from a product level may have very difficult time transitioning down to the laboratory materials level performance targets, that we are thinking about and that we're in need for in the EFRC programs that we are executing.

So the comment I wanted to bring is in terms of this balance, and also maybe in terms of how industry can best contribute to the next comment coming. I think that there's an important role for making sure that that doesn't get lost in translation. And there are some examples given this morning about some materials that have excellent possibilities of increasing active area -- sorry -- active material specific activities, so amp hours per gram of the material. That may or may not be the right metric to optimize around when you're trying to translate that into a full system.

And so keeping that tension, it's an important tension to keep, but to maintain a communication between those two sides. So you understand how material will be translated into a device, and whether the metrics need to have some adjustment or massaging to make sure that optimization around a lab metric is not going to scale the end product device.

BEN BROWN >> Thank you very much. People out in webland, give us comments. I'm told that if we get a web comment it will be printed instantaneously and brought forward. If it's a legitimate comment I might actually read it. And for those of you in the room here, we will stick to the schedule, of course, because of our online audience. So if you are feeling a little frustrated by the silence, feel free to offer a comment.

MING AU >> My name is Ming Au from Savannah River National Laboratory. I have

one comment on the balance between science research and engineering.

And this morning, David pointed out the cost of battery is a basic issue to prevent massive application, any hybrid vehicle or future electrical vehicle. And in terms of cost, materials cost, this issue is not a measure issue. Measure issue is cost of manufacture. The current manufacture is very complicated to process, and also has some environmental concern associated with that process.

But my question is based on the goal of the basic energy program, we studied the scientific phenomenon from atomic or electronic variable. That's a little far away from engineering improvement. The engineering basically is based on new technology. Maybe some technology will be inspired from basic research, but I think that the distance is a little far away.

So how to balance the engineering need and also the basic science research, I think they're both a little conflicted.

So if we involve the engineering aspect in basic science research, and the scientists or engineer have to collaborate, and not only for that, some scope of literature is purely prior, so that I wonder if the struggle between both the science and the engineering, of course they can live together, but the timeline is very long. Thank you.

BEN BROWN >> Thanks very much for that.

GRETCHEN BAIER >> I'm Gretchen Baier with the Dow Chemical Company, so my position is probably going to be clear from the beginning. But as an engineer, I have a little bit of a conflict from -- I view engineering as science, myself.

But regardless, I think the power of the hub is creating that continuum in one place, right? And so every spot in the value chain, and I think that starts with basic science, but then it's also, you know, having the materials developers and cell manufacturers, and bringing those pieces together. And I do like to comment on how to reconcile the time scales of basic research, and that in a finite period of time with the hub that might not be achievable. However, it still fits a timeline, and if this hub is successful, and that's how we all need to think, it could have a life much longer than the initial one envisioned.

So I think incorporating that complete vision from the beginning, even if it's a narrow scope, I think the chances of success are higher. So. And then I'll be back later to comment on the role of industry, but I also think that bringing the different pieces of the value chain together reduce some of those conflicts as well.

BEN BROWN >> Thank you. Well, maybe I'll poke you by just rereading the question, but eliding it with a thought. What is the right balance between science and engineering research for the proposed hub? Is there, in this spectrum, are there advantages to skewing to one side or the other depending on the research scope?

RAGAIY ZIDAN>> My name is Ragaiy Zidan, I'm from SRNL. Actually, I would put it a different way. I would say how to achieve a balance, instead of like what's like apparent. And I think since I've been working in both areas, applied and basic science, I think the most important thing is awareness, and which many of you talked about that earlier, in early talks. Awareness. If you are aware of what's in the other area, either

engineering or basic science, somehow you naturally get directed. And I believe in this evolutionary balance. You naturally get directed to seek, even if you're basic science, the direction that could be the most optimum for application. And you also get directed to ask the right questions to the basic science if you are on the other side of engineering.

Which really brings the hub to be a natural way of having people in one place, and that awareness comes a lot closer.

Last thing I wanted to say, I think this meeting, these kind of meetings we have now, are very, very beneficial, because you get people from different areas that become aware of what basic science can provide, and also what the basic science people of this country will also see what the manufacturers are looking for.

BEN BROWN >> Thank you.

MICHAEL ANDREW >> Michael Andrew from Johnson Controls power solutions business. I'm going to mix and match here a little bit and talk about this topic and also slide into how best industry can best contribute. But I think in terms of balance, our perspective would be perhaps balance isn't even the correct word, it would be more of how do you determine what correct resource deployment should be, period not necessarily saying there has to be a balance.

In the sense that if we go on to topic 2 now, then I'll back up, if we talk about how can industry best contribute, I think it's standpoint of perspective. There's the obvious area where, at least hopefully from the standpoint of program management and product launch disciplines, we could be able to assist in terms of staying on schedule, within budget, and so on.

But I also think a real key is to make sure that when the program strategy and resources are laid out, that we're talking about the right application targets, and we avoid that tendency to say let's jump down to some kind of sub-functional level, and nail down a certain quantity. Let's make sure we're looking up at the final application, set those requirements, and then everything else backs out from that, in the sense of like a product design for 6-sigma activity. And that will give you clarity about not only what you really need, but what your tradeoff opportunities are. Things like, you know, maybe you don't need the world's best active material if you have a better thermal management system, so on, there's a lot of those examples.

And then I think the other piece of it is in addition to this let's say product level requirements matrix, where industry I think can really help is what I call a commercialization requirements matrix. So even things as mundane -- you know, it sounds a little silly, but it can be true. Things as mundane as have you designed your final product to allow you to use the most reliable and lowest cost dunnage for when you get into your transportation mode. And that kind of thinking as an example I think allows you to say that no matter where you draw the line in the hub program for precompetitive versus post-competitive, that kind of thinking from the top application cascading all the way down through all the features of the product and your business goals, gives you the best shot for success independent of where industry takes results and runs with them. That's a whole other set of decisions.

But it's all that kind of perspective around commercialization. Like I mentioned,

dunnage, and even things like what might be other applications for components and materials that have nothing to do with batteries but can help you with economies of scale. It's just that kind of thinking that allows you to launch the hub and whatever programs you select with the best possible chances for success. Thank you.

BEN BROWN >> Thank you. Well, it seems like that question has expired. So let's move on to the next one, the two o'clock question, which our previous commenter graciously kicked us off in a great direction. How can industry best contribute to the proposed hub? Again, although this is sort of a one-way street, you shouldn't treat it as a one-way street amongst yourselves. If there is a conversation that happens to break out in the room, we'd be most delighted.

ASHLEY PREDITH >> I'm Ashley Predith, I worked for the University of Maryland EFRC. I just have a quick suggestion, which is that if this was my EFRC, what I would do is I would ask people who are sitting near each other to spend maybe five minutes talking to each other about the question, then I would have them come up to the front and answer it. I don't know if people are amenable to the idea, but I know there are a lot of people I don't know, but I'm sure I could have a good conversation with them before bringing my questions up front. So if people are interested in that, maybe meet somebody around you and start talking.

GLEN MERFELD >> Hello, I'm Glen Merfeld, I'm with GE Global Research. First of all, I would like just to say I was pleased to see the scope that was laid out in terms of thinking about all the way from basic research all the way to demonstration, prototype, representing industry. We want to drive it more to that side that anticipates some of the questions that are going to derail this once you get into the real world.

I think that's certainly a role that industry needs and really wants to play, I know I'd like to play that role. I think other folks in industry want to make sure that our investments can bear fruit, and we can help out doing that.

I think it was highlighted by the gentleman from Johnson Controls, as well, even if you have a technology that meets all the aspirational requirements that you've laid out, that's not sufficient. Right? It's necessary, but perhaps not sufficient.

So I think when you get into some of the market conditions and some of the economic factors that are realities, it's the people that are out there trying to sell products into the space that can help inform that.

So when you look at industry I think you should look at industry to be a partner, and maybe perhaps manufacturing needs technology some day, taking these technologies and putting them into products, and actually perhaps even being an investor in some of these early stage technologies. I think they can play all those roles.

One factor that really we can't be surprised by, so we should be talking about it early on, is around reliability, and repeatability. It gets to the statistics comment, again, that was mentioned earlier. So I wouldn't want that to be a surprise five years into a project like this, and I think that's something we can anticipate.

Lastly, I'd just add that -- and this is probably understood, that some of the scope that was laid out in terms of being able to address both transportation as well as grid applications, the technical solutions may not be the same. So it's $25 million a year,

whatever it's going to be a year, sounds like a big pot of money, but once you start slicing it and dicing it into potentially a big application space and trying to address different TRL levels, it might not go as far. But just recognizing. I'm glad that you've made the scope as large as you have, but it will place a challenge. Because I don't think you can necessarily expect those technologies to solve every problem. Thank you.

BEN BROWN >> Thank you very much.

KATHERIN HAMILTON >> Hi. I'm Katherine Hamilton, I'm policy director for the Electricity Storage Association. And the ESA is a group of about 150 companies that are all different technologies, all different applications on the grid. Most of which have been very dependent on initial funding and continued funding from the Department of Energy. So we're incredibly grateful for all the programs that have really started our industry.

I would say from a policy standpoint, and we're trying to look at policies that are technology neutral that really will help the entire industry move into the market, one of the issues we're finding is that funding is not readily coming out at this point. And I know you all are under a CR, so it's not even able to start the hub.

I think intuitively, policy-makers will know that there are efficiency gains by working together, and across programs. But I would just suggest to you that really putting metrics on those efficiencies to show how you are saving within the government, and really maximizing and leveraging the resources across programs, is going to be very, very helpful to your cause.

I also think that any kind of tracking you can do on economic benefits, new manufacturing basis that you create, job potential, is going to be incredibly helpful. And I think the role of industry in part is going to be to help you tell that story. But for us to tell that story, we need that information from you. So we want to be supportive of the hub, we want to make sure that it's sufficiently funded, but we also need to be able to tell that story in a compelling way so that it can continue throughout the years. Thank you.

BEN BROWN >> Thank you very much.

BILL ACKER >> Bill Acker again from New York BEST, to follow up the comments that Glen Merfeld made from GE and Catherine just made.

First off, it's very, very important that we have industry input into guiding the direction and the goals for the end-use products, and percolating those down with whatever sets of metrics into goals of the labs, I was happy to see that this morning and I think that's critical. So having advisory groups having links to industry for the hub is very, very important.

I do get concerned, and Glenn made the point very well, that the pot of money is not fundamentally large enough to do everything. And the idea that we've carried it very far in engineering from multiple fields becomes a challenge.

So industry linked back in a way where we can have it be a bridge to product, but not to have very large direct engineering attempts toward product, I think is very, very

important. And that then leaves a gap. It leaves a gap in the whole testing and qualification and how things work together with the industry and the hub and the existing programs.

So I believe there is an opportunity to have the hub be more scientifically based and have very, very good advisory capacity from industry and links to industry. And New York BEST is now up to about 85 members, most of which are industries in the energy storage space and very, very eager to work with the hub. We are eager to, and so are our members.

Having an interadvisory capacity, a link to create specifications and targets, and then having another vehicle by which you actually can start to measure those targets and validate product becomes very, very important. Thank you.

BEN BROWN >> Thank you for that.

MIKE PERRY >> Mike Perry, United Technologies Research Center. I'd like to applaud that this does include the grid, and when we talk about industry's role in terms of setting targets, I think that's always an important role.

What I want to point out is that the targets in the grids side I think are fairly ill-defined relative to the targets in the vehicle side. I mean, it's a much harder problem, for one thing.

As Mark mentioned, you can look at these reports by EPRI or Sandia or ESA and there's 17, 25, 30, whatever, something like that, applications. So that's part of the problem. The other part of the problem, it's not a handful of end users like there is in automotive, there's a handful of all the ends you can go talk to. In the grid side there's a whole host of customers from utilities to electricity customers to others I won't belabor here.

So my point is one of the things that needs to be established on the grid side, in my opinion, is much better targets. And these reports don't really do that, they just give you one simple example, which is in an energy application, meaning something like Pete shaving every day, there's a lot of energy being exchanged in and out of the storage device, and round trip efficiency is no doubt very important.

But the capacity application, as they say, which means maybe you're having this thing on board so 10 days a year you don't have to have an extra power plant because it's a peak summer day, a round trip efficiency is not so important. And yet we have sort of these things that say round trip efficiency will be X, and it really varies by the application.

So there's a lot of definition on that side that needs to be done, and I think it would be appropriate to have that with like a tech team helping to establish what those requirements are. Thanks.

BEN BROWN >>Thank you.

DOUG FREITAG >> My name is Doug Freitag. I work for multiple companies, but I'm here for Dow Corning Corporation here today. I'd like to address a couple different things, and it kind of goes towards what your potential selection criteria might be and it fits in with the industry piece.

One of the main things that we saw during the PVMI, the PV manufacturing initiative, the proposals that were developed, was IP. One of the critical things you're going to have to address is IP for industry to be engaged with this hub, for what you want to do. And so I would consider putting in the criteria something around somebody being creative on how they address IP, and make IP accessible to industry beyond just by dole, because of what you're trying to do.

The second thing is small business. There is a significant amount of money out there being spent on batteries throughout the world, but I think so it's easier for the large business to participate, and I know that they will want to participate, but it's much harder for the small businesses.

In small businesses, I've had a number of small businesses say they would like to participate in this, they're anxious to see how the teams address the issue of small business, but I would consider a criteria in there that says how you're going to bring small business to this.

It's harder for small businesses generally to participate, they don't have the money. Depending on how it's structured. And they're not (inaudible) membership, that becomes a (inaudible)

The third piece I would consider is a lot of the companies in the United States that are trying to get into the supply chain or manufacture are global companies. Some of the DOE activities often exclude the ability for non-U.S. pieces of global companies to participate in these types of activities.

I know the PVMI was that way, it had very specific language in that, and so I would consider, when you're writing up the FOA or whatever instrument it would be, is a mechanism to allow foreign participation. Not only on just the basic science piece, but throughout the hub process. And there can still be limitations to the benefit of the U.S. taxpayer, but as I mentioned, a lot of the global companies have extremely good expertise in other parts of the world that we're foolish not to leverage.

And the final thing I'd like to say is I know that you're going to be going from basic science to applied science throughout the technology development cycle. I guess my view is that there's already a lot of money going into basic science issues, is that if you are leaning toward a lot of the activity in basic science, it's really no different than what DES funds today. And I think the advantage of the hub is take basic science that's being invested in today and put a focused amount of money to be able to take it to the next step, to fit that bridge between basic science and industry, what industry needs.

But at the same time, leave the ability that as industry brings problems or problems occur, it does feedback and allow the development of new basic science that's not being done. So I'm not saying exclude basic science. I'm just saying don't use it as a -- it's just a pot of money to fund more basic science. If that's the case, we can do that within BES, and there's no use doing the hub. So thank you very much.

BEN BROWN >> Thank you very much.

GRETCHEN BAIER >> I'm Gretchen Baier with Dow Chemical, again. Several points here I'd really like to validate or comment or emphasize, agree with, the previous commentary. Specifically, on IP, the importance of that. I'm in Dow's external research group where we set up collaborations, all sorts of them, and we then involve with some

of the previous hubs, the applications, we've won some, we've lost some, we've decided not to apply for some. In hub-like type of activities, not just in the U.S. as well, but around the world. And it does come down to IP, and some of our -- has been pretty disappointing. So if it's not defined up front, then, you know, we end up with a collaboration that's not really not collaborative. So we'd really like to emphasize the importance of that.

Assuming that there will be industry participation, which leads to my next comment, which I find this question interesting in itself. How can industry best contribute. Because I don't see a line item for how can universities best contribute nor do I see a line item for how can national labs best contribute. But not to pick on these other types of organizations, however it does feel a little in the bull's eye here.

Because I think that as the previous speakers have mentioned, we have a lot to contribute, in setting the direction a little bit, or basis in reality. Maybe removing some hurdles, and then providing paths to commercialization as well. Some comments on the rest of the world because this slide does say this is a rate not just domestically, and we see activities in Europe, or China, where it does (inaudible) complete value change, so how -- they're addressing this value. And that's where I think the potential of the hub really occurs, because we're members of multiple organizations, the council for chemical research, the university-industry demonstration partnership that's sponsored by the National Academy of Sciences, and all these organizations, collaborative organizations, everybody can read this as well, that's the whole point of Bayh-Dole and things like that as well, is how to bridge that gap. And that's certainly difficult but that is where the opportunity is, basic fundamental science activity, I don't see how it's differentiated from the EFRCs, we don't participate in those (so maybe I don’t have a great understanding of the EFRCs, besides its being larger, so I would very much look forward to that really difficult area there).

BILL ACKER >> Bill Acker again – the comments this morning were excellent, and I really got a lot out of them, so thank you for those. To follow up on the last comment on IP and industry link and how firm that link is, one bit of feedback that we've gotten from a number of our members is that they're very interested in participating and cooperating and being -- having a conduit for (inaudible), but they're also very concerned about a unilateral, monolithic path that may either block them out or lock out their competitors or limit a technology's pathway to market. So a comment we've gotten in a number of cases is they're concerned with too-firm individual links of industry to the hub as opposed to collective industry (inaudible) consideration. Thank you.

DOUG FREITAG >> Doug Freitag again. Just one added comment was you saw in the presentations this morning, (inaudible) I noticed -- I wanted to mention in the talks, and it's been stated frequently, that cost is our biggest issue with energy storage. And cost isn't necessarily a basic science issue, or applied science issue, it's a manufacturing issue. And a lot of people don't consider manufacturing a science.

The manufacturing guys, some of them will argue with you.

I would encourage you to consider within the solicitation that whatever hub you set up, that they have a manufacturing aspect to that. And it could be a manufacturing technology, manufacturing science. We don't need more basic science that is not

scaleable and cannot be transitioned into manufacturing.

And I think that's a critical area, where industry can participate and provide guidance, is on the manufacturing aspect of it, to make sure where we're spending our money can be scaled and can be transitioned.

And so I would encourage you to consider that. Thank you.

BEN BROWN >> Thank you very much. We have an online comment. Which I will read. I'm going to channel Joe Gordon from Applied Materials.

"This is Joe Gordon from Applied Materials.

Here are several ways that industry can participate effectively in and enhance the programs in the hub.

One is to be an advisor with a role in guiding research activities that are carried out in the hub. Another is to be an active participant, partner, in some of these activities. This is a very effective way of ensuring that an activity addresses an issue that is important to industry.

Lastly, industry can provide capabilities at their sites that will not be available in the hub. I understand that such collaboration will be a challenge, but is one with high payoff and closely connecting the academic and national lab partners with actual manufacturing issues."

Thank you, Joe.

GARY RUBLOFF >> Gary Rubloff again, University of Maryland. I'd like to second your comment about manufacturing as a science. I strongly believe it's a science. I used to do manufacturing research when I was in industry, and I continued in the university. And so much of what we get out of materials depends on how we make those materials. That depends on the kinds of equipment that's available to do that, applied materials is a good example of that.

I think there's tremendous science all the way down to what most of us would call surface science, in the way equipment is put together, with chemistry, and physics, to be able to make the kinds of materials and structures that are necessary here.

And I think there's another really important dimension to manufacturing research as a science, which is kind of above the base tech level, where you're talking about materials and devices, but now you're talking about how you operate a manufacturing plant. And you start thinking about not how much equipment costs, but what its real cost of ownership is. And the kinds of modeling that is done routinely in industry for all of these things, that I think isn't very well appreciated by the basic research and university community.

And I know that many of my colleagues in academia wouldn't recognize these things necessarily as having a fundamental scientific component to them, but it really is there.

And so I think everything you're saying is important. Normally we don't think about cost, as what we're concerned about. How are we going to affect cost. But when you really get down to how things are made, in manufacturing equipment and in sequences, in these manufacturing processes, those things really do turn on very fundamental science issues.

BEN BROWN >> Thank you. Are there any more comments for this question? We've had quite a nice discussion so far.

MING AU >> My name is Ming Au, from Savannah River National Laboratory, for the two previous speakers, the comments. And of course, the science always leads to new technology, new equipment, like the laser discovery, right? But it takes a long time. Takes a few decades before you have a useful laser tool to cut steel or shoot with an aircraft.

Right now, in energy hub, hub has limited timeline. With a limited timeline, you want to accomplish something. You don't want to let people be disappointed who supported you. I think for basic science, you could do endless literature, but with budgeted funding determined by politicians, if politicians lose interest, and general public lose interest, it's harder to get back to track.

So I think for the hub, within time allowed, we need several things. One, long-term very fundamental research, keep science advanced. Meanwhile, you need to accomplish something within the time allowed.

So that I think if we organize a hub we probably need to think of those two things. Or you can divide the two groups, one is very fundamental science research, one is -- I don't want to say the target whole either, I want to see very a priori research. Eventually you can bring something to manufacture, like an advanced needed tool, or a whole new process to replace a current process. Your current manufacture process of a battery has existed for a long time, so there's no fundamental change. It all goes through a very complicated process, and each process introduces a quality control problem.

So that the science, basic science, you hope can do something, and the researcher can go to small scale demonstration, this manufacture process is totally different from the traditional. That should be correct. But I think if you start from scratch, develop the science, until you have some useful equipment or technology. So timeline in there, and we'd be challenged by delivery, any project that you have delivery. We need to continue to get support from all aspects. Whatever the Congress supported, whatever the general population support, keep the program going.

That's my point. To construct the hub, we should consider long-term goal, or short-term goal. So we have to balance that both. If we would go to a solid session we need to emphasize fundamental research, also sort of the a priori research already detailed to deal with some manufacturing engineering issue. Thank you.

BEN BROWN >> Thank you for that.

WILLIAM MAYS >> William Mays, Energy Conversion Devices, Erbonic Battery Company. I think industry can bring a lot to the table, but I think -- as far as R&D and bringing up manufacturing facilities and helping to monetize ideas. But I think the biggest problem that industry has jumping into the mix is unsure. Because of the way the government swings back and forth between technologies, and based on whatever political party is in government. It would be nice if there was some stability, some -- some way, some mechanism to give industry a little more feeling that there's going to be support or some sort of legislation in place that can help continue this on beyond the next political party.

BEN BROWN >> Thank you. Do we have any more comments for this session? All right, well, we will stand, then, in recess during our break until 3:00 p.m. Thank you very much for a lively discussion.

(Break.)

PATRICK GLYNN >> Okay, I think we're going to reconvene, if people could find their way to their seats. Those of you stalwarts who have decided to remain for the last session, we had a little powwow at the end of the last session, and unless there's a strong objection, the proposal was to foreshorten the three planned comment sessions into one comment session, rather than to sit here in meditative silence like so many monks waiting for someone to offer an insight.

So the plan would be to try to go for maybe another 20 to 30 minutes. You can speak to any of the three questions, and I would say let's be flexible, especially since the last comment period was designed to be kind of grab-bag period. We're really happy to hear comments on any -- on any subject of your choosing. And I'll remind you know we have this -- it's been a little bit of a peculiar situation, but this non-Q&A has been instrumental in enabling us to reach out to the community and provide the information without getting into kind of complexities that affect the way that we make a selection. And so -- we appreciate that you've borne with us, and we think we've learned a lot. I know sitting there I learned a lot from the comments in the last couple of sessions.

And let me add that, especially for those that are tuning in via the web, that the comments will be -- and correct me if I'm wrong, Linda -- you'll be able to comment for the next seven days. The presentations will be up -- or the meeting video, will be up for the [one year] (correction), and certainly as soon as we can, we'll have a full transcript of the meeting for people to access. So this is very important that people's access to this information is not determined by whether they were able to fly to Washington on this particular day. And that's been driving a lot of the nature of this meeting.

And we hope that despite some moments of awkward silence, shall we say, that the information that has been provided has been helpful, and we certainly are gaining a great deal from listening to you.

So without further ado, we'll just open the floor. We'll go for 20 minutes; if people start charging the microphones en masse, we can extend it.

I should read the questions, yeah, good idea. Okay. We've got three.

Is the proposed research distinct compared to other research and development activities supported by the DOE? Are there underpinning scientific issues in electrochemical energy storage that were not discussed in previous workshops or reports that we should be taking notice of?

And then we're also, as I said before, open to general comments on the overall DOE program on batteries and energy storage.

So we'll give people a few minutes to gather their thoughts. We can wrap up even sooner if there is no additional comment.

The video is going to be up on Monday. So it will be up on Monday, I guess Monday through Friday? All right, good.

GRETCHEN BAIER >> So Gretchen Baier with Dow Chemical Company. I think definitely the proposed research, you know, could be distinct compared to what's going on, you know, funded by the DOE in other areas. I think the potential is certainly there, and we're very excited about it, and looking forward to, you know, what it could be.

I think some of the comments earlier, though, it might not be how we envision it. And so, you know, if we could fill in that valley of death through this, that would certainly be a real positive, and make it very distinct.

And so I'm viewing this more as -- as the gap in the past to -- you know, making technology viable, as opposed to the specific technology itself, on where that's unique. It's one of the mechanisms.

PATRICK GLYNN >> Thanks very much. Okay, well, we've got another web comment which I'll read. To do so I'll need my glasses.

This is a comment on how industry can contribute, and this commenter agreed with the last comments, I'm not sure which ones those were. The writer goes on to say the government and politics have changed the programs they want to support. It is hard for industry, in some cases academia, too, to keep up with those changes.

For example, the previous President supported H 2 production. My Ph.D. work was supported by that funding. Now this government is putting a lot of emphasis on energy storage, parentheses, lithium batteries. We should follow or learn from the Japanese system, where the energy policy has not been changed in the last 15 to 20 years, even though there have been different prime ministers. And that's actually from Peter Aurora at the Nissan technical center in Farmington Hill, Minnesota -- or Michigan, I guess.

DOUG FREITAG >>Doug Freitag. On some of the presentations this morning, and I don't know if it will be covered within the solicitation, you indicate the desire to not use critical materials, and the desire to make sure the batteries are safe.

I guess I personally don't feel like the government and DOE's in a position to say what is a critical material. I think that's an industry. There's a lot of discussion right now on rare earths, and there's a lot of debate over the issue of rare earths. And I think you want to be a little bit careful on that, because you could have a great idea that depends on a potentially critical material, but I would -- that said, that's a debate that I think industry has to weigh in on. It's not necessarily something -- it's a little bit hard for the government to make that kind of a decision. And we may throw out the baby with the bath water by making those kind of decisions prematurely.

And safety is a little bit more I guess easier to do, but on the critical material issue, I would just ask you to be a little bit careful on how you do that.

PATRICK GLYNN >> Thank you very much.

JIM HODGE >> Jim Hodge with K 2 Energy Solutions. And one of the challenges for industry and especially small business in working with DOE programs, and understand how we work with DOE programs, is how the intellectual property is handled. Especially for a program that is dealing with technology that's approaching commercialization.

And I don't doubt that the DOE has given that a lot of thought, but it would be

useful if that was kind of laid out clearly for small business and industry in general, as to how you plan to handle intellectual property moving forward.

PATRICK GLYNN >> Thank you very much. I think it seems there aren't going to be too many more comments, and so I'll say thank you. I guess we -- thank you for all of your comments and contributions, they're truly appreciated. I look forward to reading the web comments that are accumulated over the next seven days. Certainly anyone here that wants to augment their comments with an online, more detailed response, that would be very welcome.

I had a correction from Katie, the actual video will be archived not by DOE, but offsite, so through the link for this meeting, for the next year. So it will be available for -- this online -- the online webcast will be available for people to reference over the next year as they would like to refer to that.

And again, we will have a transcript of the meeting, including the electronic comments, compiled and posted as soon as we can. Thank you very much, and please continue the input. We look forward to hearing from you all. Thank you.

>> Thanks very much.

(Meeting adjourned)

Comments from Batteries Inbox

October 26, 2011
Michael Norman
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With the demise of the large industrial laboratories like Bell Laboratories, and intense competition from such places as China, companies have been forced to restrict their investments to short term outcomes. Therefore, the longer range basic research needed to make truly technological breakthroughs no longer occurs in industries, at least in the US. As a consequence, it is imperative that the only entity that does make such investments, in particular the US government, step in when national interests are at stake. This is the case for energy storage. If we want to cut our dependence on foreign oil, then it will be necessary to develop battery technology that will enable, for instance, electric vehicles to replace gasoline ones. Without an order of magnitude improvement in current performance, this will not occur. Therefore, basic scientific research, as would be enabled by the proposed DOE Energy Storage Hub, will be critical to make this vision a reality.

October 27, 2011
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First of all, Dow would like to commend the DOE on the Hub concept. Other countries have more avenues for government – industry – university partnerships and this is an important step in enabling US competitiveness. Dow participates in many different collaboration modes around the globe, ranging from pre-competitive consortia, to bilateral sponsored research (fundamental to applied), to government contracts, to trade organizations, among others. Each has its strengths and weaknesses. The Hub, in particular, offers the possibility of bridging "the valley of death", that is, the hand-off from fundamental research to applied. Such bridges are not easy to build, but do offer the greatest potential. A bridge requires industrial involvement beyond pure monetary contributions and attendee at project reviews; this involvement can be one of two forms (1) advisory or (2) participatory. Participatory provides the strongest foundation by the industrial partner "having skin in the game". At the same time, participatory is more complex (and provides higher commercialization potential) as the IP terms must be consistent with the industrial partners' commercialization strategies. This does not mean that, on one extreme, that the industrial partners have to "own everything" or, on the other extreme, that the industrial partners have to provide free access to foreground and background IP. It does mean that all parties agree up-front on an overall strategy.

The proposal stage is the appropriate point to start these discussions and execute MOUs. It can even be productive to require MOUs and provide enough response time to execute. When expectations are not set up-front, there may be several sub-optimal outcomes, including participants having a passive role in order to not risk IP yet still part of the "collaboration." One way to minimize IP conflicts is for the collaboration to involve one member of each step in the value chain. This concept is particularly relevant in the complex field of energy storage. Not only for IP concerns, but also to better connect fundamental material properties to performance metrics. Dow has found in the past that the proposal process (shaping the project, defining roles, discussing terms) leads to collaborations whether or not the team is the final awardee. Providing the initial incentive to set up collaborations is a less measureable, but important role of the solicitations.

Katherine Hamilton
Quinn Gillespie
Director, QGA Public Affairs
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Thank you for the opportunity to comment on the Battery and Energy Storage Hub at the Department of Energy. I have had over 25 years of experience in the energy sector, including starting my career as a distribution engineer for an electric utility, becoming a Certified Energy Manager for increasing energy efficiency in commercial and government buildings, leading cooperative research programs as well as managing Government Relations for the National Renewable Energy Laboratory, and running the GridWise Alliance which focused on smart grid. In my current role as a Director in the QGA Public Affairs energy practice, our team helps clean energy companies – including solar, wind, electric vehicles, recycling, energy efficiency and energy storage—to navigate public policy.

I listened with interest to the presentations on the Battery and Energy Storage Hub on October 21, 2011 and paid careful attention to the goals underlying the various research and development thrusts. ***I wanted to advise the program leaders to ensure that the research goals are defined by metrics that support long term national interests and public policy rather than political messages.*** *I have watched programs that had political support like the Partnership for a New Generation of Vehicle (PNGV), die by the wayside when a new administration came into the White House. With those programs, an enormous quantity of powerful and productive research was also buried. For example, instead of making the goal of battery research and development "one million electric cars on the road by 2015", the goal would be tied to metrics like barrels of gallons of imported oil reduced; or tons of greenhouse gas emissions lowered; or even transferability of research to manufacturing and jobs. Disconnecting the R&D goals from political messaging (while certainly supporting that messaging) will allow for that research to have life beyond any one Administration. Research is by nature long term; our political cycle seems incredibly short by comparison. Ensuring that research metrics support longer term public policy goals and then making that progress available to*

policymakers, your important efforts will be able to make the case for continued funding by Congress as smart public policy.

I would be glad to assist in any way to review or define the metrics for this Hub. The holistic research approach you have proposed is critical to the success of energy storage in the markets. Thank you again for the opportunity to comment.

Gerbrand Ceder
Massachusetts Institute of Technology
Professor of Computational Materials Science
gceder@MIT.EDU

In response to the DOE request for Comments on the DOE program on batteries and energy storage, I offer this:
The Hub will fulfill a unique role, and create its most optimal impact, when it executes the basic science works that fills the innovation pipeline. Clean sheet of paper thinking, new ideas, novel concepts, substantiated with good science. Such is needed to move energy storage into new territory and deliver the breakthrough technology ideas which can then be handed off to industry. There is no better place to operate this than through the combined power, infrastructure and talent of the national labs and universities.

October 28, 2011

Holly Coghill
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A general comment on the upcoming energy storage hub FOA. In the past, the hubs have required a one roof model to promote the collaboration that is required to make a successful hub. While we recognize this is an excellent model to promote integration and collaboration resulting in new ideas and innovation, the many unique user facilities through the US make it nearly impossible to actually perform the work "under one roof." In addition, the one roof requirement might discourage adding members to the team because the physical location is not proximate to the lead entity. Therefore, the result of this requirement may actually discourage US collaboration and innovation, directly opposite of its desired outcome.

Mark Peters
Argonne National Laboratory
Deputy Laboratory Director for Programs
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With regard to the DOE's question/comment, "What is the right balance between science and engineering research in this area?"

My response to this question is provided below…

The right balance is to have both, much as outlined in Dr. Horton's presentation. There are great unknowns in the field of electrochemistry, so there is a clear need for fundamental scientific research. The translation of that fundamental research requires a component of engineering to reach its full impact in society. Having that combination in a single endeavor is the real opportunity for the Hub.

Jeffrey Chamberlain
Argonne National Laboratory
Department Head, Electrochemical Energy Storage
Energy Storage Major Initiative Leader
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To whom it may concern,
I am writing to respond to the question posed by the DOE in the Hub information meeting Friday: "What is the right balance between science and engineering research in this area?"
My comment is that the work in the Hub should be predominantly scientific research, but with sufficient engineering research to ensure an effective transition of breakthroughs from the lab bench to commercial realization in industry. When deeper insight of the nature of materials is gained through the scientific research, more effective and efficient product development by industry is enabled. The combination of fundamental scientific research with engineering science will enable a smooth and rapid transition to market impact. In preparation for the coming opportunity, we have also validated this proposed balance of science and engineering research in a potential Hub activity with various possible industrial entities.

Andrew Gerwith
University of Illinois at Urbana-Champaign
Director, School of Chemical Sciences
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I wish to submit a comment following on the 2011 Batteries and Energy Storage Research Information Meeting. I'm sorry that this is a week delayed. I specifically want to address the right balance between science and engineering research in this area. My comment is this:

Part of the balance between science and engineering will be to educate and train the next generation of both scientists and engineers, furthering the building of an ecosystem that advances the field, not just to advance a device.

I hope you find this comment helpful.

Michael Thackeray
Argonne National Laboratory

thackeray@anl.gov

Herewith my response to the question: 'How can industry best contribute?':

Response: 'Industry's role will not only be to commercialize a full system, but also to take advantage of singular innovations and apply them to existing products or new product development that they self-fund because it will add value to their on-going business.'

Michael Thackeray
Argonne National Laboratory
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Herewith my response to the question: 'Is the proposed research distinct compared to other research and development activities supported by DOE?':

Response: We anticipate that the Hub will provide a great opportunity to leverage the basic science emanating from the EFRCs and to take advantage of the breakthroughs in science emanating therefrom.

Alex Fay
Quallion
Business Development Manager
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Thank you for the opportunity for Quallion to share its feedback on the proposed Energy Innovation Hub for batteries.

Quallion is a California based manufacturer of lithium ion batteries for medical, military, aerospace and green technology applications. Quallion operates a vertically integrated manufacturing process, including producing active materials, manufacturing cells, designing electronics, assembling cells into modules, and integrating final battery packs.

Quallion has worked closely with the US Government to develop energy storage solutions for defense and reconnaissance applications. Most significantly, under Title III of the Defense Production Act, the US Government has awarded Quallion contracts to build and operate production facilities to ensure a domestic, US owned supply of key active materials and cells for use in satellite applications. Quallion has also done work for the Department of Energy to develop a prototype battery HVAC system to eliminate diesel emissions from heavy duty trucks when idling, and it is underway on a project to develop a hybrid high energy-high power battery through the US Advanced Battery Consortium.

Quallion has four primary comments with regard to the development of the Battery Hub. Firstly, the DOE should consider the significant investments in battery technology made by the defense department and related agencies. Secondly, DOE should also consider incremental steps towards vehicle electrification, such as battery air conditioning idle reduction systems, as valuable progress towards a fully electric fleet. Thirdly, it is important that the US recognize the significant advantages of Asian producers in commodity battery systems and instead focus on advanced technologies where US industry can offer a competitive advantage. Finally, the Hubs should work to strengthen regional partnerships between industry, government, universities, and national labs to lay the groundwork for lasting technology development and job creation clusters.

While the information meeting regarding the battery hub was comprehensive in reviewing DOE's work on developing advanced batteries, Quallion feels it is also important to consider the technology development efforts at other federal agencies related to batteries. Specifically, the Department of Defense and intelligence agencies has made significant investments in battery technology to enhance the capabilities of forward operating bases, satellites, launch systems, aircraft, ground vehicles, soldier radios and devices, and other applications. Some of these projects are directly related to DOE's goals of enhancing storage options on the power grid and advancing electric vehicles.

Just as defense investments have helped bring innovations like the internet and GPS to commercial viability, so too will military investments in battery technology help expedite the adoption of grid scale storage and electric vehicles. Quallion has done a significant amount of research and development to support the military applications of batteries, and the company has developed significant expertise in production for military applications. Generally, military requirements for performance and ruggedness exceed those in the commercial market, and the military is willing to pay a premium to develop advanced technology. This makes the military an ideal early adopter of battery storage technology that can help cover development costs as industry scales up to meet the needs of the commercial market.

Just as the DOE has considered hybrid electric vehicles and plug in hybrids key milestones on the path to a fully electric passenger vehicle fleet, DOE should also consider other incremental vehicle electrification efforts that help increase production volumes of advanced vehicle batteries. One such application that Quallion has experience in is a lithium ion battery powered HVAC system for heavy duty trucks. This 6kWh, high voltage battery powers a dedicated HVAC unit that can provide 10 hours of cooling for a sleeper cab truck, eliminating the need to idle the truck's main engine or use a diesel fired auxiliary power unit. The battery is charged in 3 hours of normal truck operation via the truck's alternator, or it can be plugged in to 120V shore power from the grid if such facilities are available. The battery HVAC system will pay for itself in about 2 years based on fuel savings alone.

While this battery system does not provide any propulsion assistance to the truck, it does significantly reduce lifecycle truck emissions by targeting the low hanging fruit of idling emissions. Commercial truck fleets, which are generally more savvy about total cost of ownership than consumers, will be faster to adopt compelling lifecycle business cases for vehicle electrification. This can help support the production volumes of batteries, and it also acts as a bridge to more significant truck electrification, such as idle stop-start systems. Idle stop-start systems would have additional applications where trucks are queuing or stuck in traffic, conditions that are present near ports and urban areas that suffer from the worst air quality.

Thirdly, recognizing the advanced state of high volume battery production in Asia, the DOE should focus US research and industry efforts on novel technologies that can succeed with domestic production. For example, Quallion is developing a vehicle battery for the USABC that combines a high energy module made from inexpensive commercial cells from Asia and a high power module made with more expensive, higher performance cells manufactured by Quallion in the US. This battery can provide both enhanced range via the high energy module and enhanced acceleration and regenerative braking via the high rate, high power module. This battery is a good analogy for ways to accelerate commercial applications and reduce costs by relying on commercial off the shelf parts for 80% of a project, but improving performance with 20% advanced chemistry cells. This 80-20 model could also have significant cost savings and performance enhancing potential in grid scale applications that need a mix of high capacity and high power. This model recognizes that manufacturing costs in the US are higher than in Asia, but it still provides ample opportunity for higher value, higher performance US technologies to be deployed in a cost effective way.

Finally, by working through existing relationships established between industry, government, universities and national labs, the DOE can build lasting partnerships that will continue to yield regional and national benefits beyond the conclusion of the Hub program. One such example of this collaboration is CleanTech Los Angeles, a non profit partnership of Southern California's leading business, government and academic institutions focused on developing new green technologies and creating jobs in the region. The partnership includes research institutions like UCLA, USC, Caltech, and the Jet Propulsion Laboratory. It also includes industrial partners like Quallion, Coda Automotive, Southern California Edison, and So Cal Gas Company. Government participants include the Los Angeles Department of Water and Power, the Los Angeles Mayor's Office, the Port of Los Angeles, Los Angeles World Airports, and the Los Angeles Metropolitan Transportation Authority. This consortium is a perfect example of the cooperation needed to quickly develop new innovations in a research setting, commercialize them, and deploy them among operators like utilities and government infrastructure agencies. With existing relationships in place, organizations like CleanTech LA can help fulfill the Energy Innovation Hub's goal of quickly translating advanced research into commercial applications.

Thank you for this opportunity to comment on the proposed Battery Hub. Quallion looks forward to progress on this program, and will be seeking teaming opportunities

with universities and industry that share our commitment to developing novel energy storage technologies that can address our country's energy challenges and create high quality jobs for American workers.

Douglas Ray
Pacific Northwest National Laboratory
Associate Laboratory Director
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Industry has a very specific role: They need to be brought in at the appropriate time to provide performance criteria and goal setting and to be the handoff to enable translations of the new knowledge into commercial reality.

Yet-Ming Chiang
Massachusetts Institute of Technology
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In response to the DOE stated question "Is the proposed research distinct compared to other research and development activities supported by the DOE?,' my answer is that the proposed Hub is unique and distinct in two respects. First, it will fill a large gap in fundamental science in battery research that exists today. The EFRCs cover some of this gap, but not all of it. Second, it will perform an integration function from the fundamental science through to early stage commercial hand-off, which is the real "valley of death" that basic energy research faces on the way to having societal impact.

Terry Aselage
Sandia National Laboratories
Senior Manager
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I would like to add a couple of comments regarding important issues and questions associated with the proposed Batteries and Energy Storage Hub:

Question – Is the proposed research distinct compared to other research and development activities supported by DOE? A critical aspect of the structure of the proposed Hub is the integration of fundamental research in materials science and electrochemistry with the engineering science required to capitalize on fundamental breakthroughs. Through the Hub, early engagement and integration of these functions will ensure that breakthrough capabilities are fully realized in a more efficient manner than would otherwise occur through serial handoff.

Question – Are there underpinning scientific issues in electrochemical energy storage that were not discussed in previous workshops/reports? The reliability and safety of electrochemical energy storage systems are important questions for both transportation and stationary applications. Increased energy and power densities in advanced devices

will only elevate these concerns. A scientific approach to addressing degradation, failure, and safety would be an important advance.

Yi Cui
Stanford University
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Here is my comments on one of the questions

"What is the right balance between science and engineering research in this area?"

My Comments: The balance of the two provides an opportunity to further leverage significant government investments through user facilities some of which are geared for science and some of which are geared engineering. The hub provides us an ability to leverage a large portion of the work on basic science because of the national laboratory infrastructure / user facilities. The hub will provide a mechanism to leverage the scientific and engineering assets that have already been built. It is very important to look at the next generation of battery chemistry beyond current lithium ion batteries, which enable high energy transportation battery and low-cost grid batteries. It is also important to balance adequate engineering in to show the promise of these chemistry towards commercial applications.

Delia Milliron
Lawrence Berkeley National Laboratory
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We believe that the previous workshops and the BRN report have effectively described the need to understand the fundamentals of electrochemical processes in order to enable breakthroughs in storage. One of the advantages of this funding vehicle is that we will be able to leverage experimental work and computational science to address such questions while also uncovering any fundamental issues that were not previously identified.

Joseph Gordon
Advanced Technology Group
Senior Director
Joseph_Gordon@amat.com

While is difficult to specify the balance between science and engineering (partially because the boundary between science and engineering is blurry), the HUB can ensure a connection between the two. By fabricating whole devices the HUB can ensure that the interplay between components can become clear and addressed in HUB programs. The HUB can take into account real world considerations such as cost (earth abundant materials) are taken into account early in the programs.

Nenad Markovic
Argonne National Laboratory
markovic@anl.gov

Please find attached comments for the questionnaire from the meeting;

/1. What is the right balance between science and engineering research in this area ? /

The two aspects of research, science and engineering, are interpenetrating; since the knowledge gained from the basic science research will advance the means to improve the technology and, conversely, observations from the engineering research will supply feedback challenges and insights into fundamental research. Therefore, there needs to be an optimal balance between science and engineering at various stages of the development, with science being the major focus in the early stages of development, and eventually incorporating more engineering research during the technology maturation stage of the project.

/2.Is the proposed research distinct compared to other research and development activities supported by the DOE?/

I must say that, absolutely yes. There is no one program which focuses on all aspects of technology development including fundamental and application research for energy storage. The hub will afford that opportunity to look at this area more holistically. As a result, this offers a unique setting where the knowledge gained from the fundamental understanding can be realized in a real application.

Please let me know if there are any questions/comments.

Michael Andrew
Johnson Controls
Director of Academic Affairs and Program Partnerships
Michael.G.Andrew@jci.com

1. With respect to DOE's request: Please offer comments on the overall DOE program on batteries and energy storage:

From Johnson Controls, Power Solutions business, Mike Andrew Director of Academic Affairs and Program Partnerships
A major advantage of the hub program is that it provides industry the opportunity to plant seeds that are genetically encoded, if you will, to germinate ideas beginning at the front end of the innovation pipeline, driven by basic science, that will grow to technologies with rich commercialization potential. The hub program offers the United States an opportunity to lead the world in sowing these seeds and delivering results.

We as an industry player fully support the concepts presented in the meeting Friday. Industry stands in support of the basic science effort coupled with engineering research

that delivers pre-competitive ideas that we can use as the basis for product innovations. We look forward to being at the table as a partner to help set the landscape that defines the RDD&D needs.

Ashley Predith
NEES Energy Frontier Research Center
Associate Director for Progress
apredith@umd.edu
apredith@gmail.com

Dear DOE Office of Science -
I am submitting a comment in response to one of the questions at the Battery & Energy Storage Research Information Meeting held October 21, 2011 in Bethesda, MD.
"Is the proposed research distinct compared to other research and development activities supported by the DOE?"
The defining feature of an Energy Innovation Hub that distinguishes it from other research and development activities supported at DOE is that each Hub is (1) a single very large yearly investment of labor and money under one theme and (2) is coordinated among a large number of researchers and institutions.
The particular scientific topics any Hub might pursue might be addressed in small pieces across the scientific community, but the coordination across many people and institutions is unique. One of the most critical aspects of a Hub or any coordinated organization is how the process is managed, how the leadership behaves, and how people communicate with each other. Resources and methods for improving individuals' skills in leadership, management, and interpersonal communication might be useful for everyone involved in a Hub or a coordinated scientific team, not just a few people who are highest level managers.
As you are planning for the Hubs, please consider raising those concerns in the scientific community by supporting mechanisms to discuss them just as you might support instrumentation grants or workshops on new characterization tools. The mechanisms that will be successful for teaching, learning, and applying these skills in the membership of a Hub will be unique to each group, but an important first step is bringing these issues to the same level of discussion and concern as the scientific topics being chosen.

Jun Liu
Pacific Northwest National Laboratory
Laboratory Fellow
Leader, Transformational Materials Science Initiative
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One of the industry's roles is to take advantage of the progress made in R&D on the component levels, and help apply and integrate into commercially viable systems.