DEPARTMENT OF ENERGY

QUADRENNIAL TECHNOLOGY REVIEW

GRID MODERNIZATION WORKSHOP

May 23, 2011

Scottsdale, Arizona

XXX: Morning, everybody. Thank you very much for joining us here this morning. This is the fourth of a series of workshops that DOE is holding on the Quadrennial Technology Review. We're really looking forward to the discussion and all the info we're going to get from you all today.

I'm going to run through some of the more boring logistical bits and pieces before handing things over to Under Secretary Koonin. The first is to remind you that you are not members of a federal advisory committee and we don't intend to use this group as a federal advisory committee. We're not seeking a group decision or consensus views with respect to the issues that we will discuss today or as any action the federal government should take. And we welcome your individual recommendations and advice, and we're looking forward to a productive workshop.

Also, I'd like to note that participants in this workshop should bear in mind antitrust laws and restrictions, should check with your counsel before engaging in certain activities such as collecting or discussing nonpublic data, evaluating public data about future prices or costs, or discussing topics whose legality you are unsure.

We ask you to refrain from disclosing any

proprietary company costs of supply or price information or any proprietary company information.

Lastly, we want to stress that we do not intend by this workshop to encourage any specific cooperative activity among participating companies that is not clearly authorized by current law.

So one of the commitments that we've made as part of this QTR process is a commitment to transparency and to outreach. You are here participating in some of that outreach; we appreciate that. So we have a publicly accessible website which I hope you have visited, energy.gov/qtr. We are releasing all external ex-parte communications that we receive. We have published a request for information in our framing document, and we have received over 60 comments on those documents. And we're holding a series of focus groups and workshops, of which this is one.

One thing to note is that the notes from this workshop, as well as the presentations, will be posted on the web within a few weeks afterwards, after we get the transcripts. However, we will anonymize the notes so that it's -- the words will be there, but not attributed so as to help encourage free-flowing conversation here but while still remaining open to the public who are not here in the room with us.

As I said, this is the fourth of a series of workshops. We did two workshops on the transport sector. We were in Pittsburgh last week to discuss efficiency. We're in Scottsdale today to talk about the grid, and in two weeks we will be actually in Boulder I think to talk about clean electricity. And we will have -- well, that actually may or may not be on that date. As XXX says, we're making this up as we go along, so don't hold that date too firmly.

So you all have seen a copy of the agenda, but just to run through it with a little bit of context and explanation, we will start with some opening reXXXs from XXX. We will move into a panel discussion of some cross-cutting questions that XXX will raise in his presentation, and then we'll open the floor to the full group discussion on those questions. Then we'll move across to the room across the way where some of us were having breakfast and have breakout sessions, continuing on basically using that earlier conversation as a seed for the breakout session discussions. Then we'll break for lunch. I think lunch may actually not be served until noon so the breakout session may run a little bit longer.

Then in the afternoon we'll start with some technology presentations from DOE folks, and then we'll have breakout sessions where we really dive into those

technical topics. Then we'll come back through a series of report-backs, both on the technical discussions and sort of summary report-back of the morning breakouts. And then we'll return back to full group discussion on those questions when we have the context of the day behind us.

So why don't we just take a few minutes so everybody knows who's here and just go around the room and everybody just very brief who you are, where you're from, and we'll just go around.

So I am XXX. I am a AAAS Science and Technology policy fellow. I work in XXX's office.

XXX: XXX, Under Secretary for Science at DOE.

(Inaudible gallery introductions.)

XXX: Thank you all for being here. Also I want to highlight the congregate of Arizona State folks in the choir and particularly thank Arizona State for providing logistical support and note-takers and such for today's workshop and breakouts and helping coordinate this and allow us to actually have this event here.

So with that, I'll turn it over to XXX.

XXX: Good morning, and thanks to everyone for coming for the day and participating.

This is we think a very important and fundamental exercise for the Department, basically trying to tell the story about the Department's activities in energy, why they're important, what we are doing to tell the story not only to the outside world, our stakeholders, whether elsewhere in the administration, in Congress, the private sector, but also frankly to tell the story to ourselves.

The DOE recently issued a strategic plan, the first that had been done in about five years. I had the pleasure of shepherding that exercise as well. And it's fascinating even within the Department to sit down with different stakeholders and ask what do you think the Department of Energy should be doing. And you get such divergent answers. It's an interesting discussion.

So let me tell you what it is that the Quadrennial Technology Review is about. We're aiming to provide a context and framework for the Department's energy program. So this is about the energy part of the Department. For those of you who don't know, the energy technologies are about $4.3 Billion a year. In addition, some fraction of the Office of Science, which is in total 5 Billion a year basic research, touches on energy technologies. But those two together are about a third of the Department's total activities. We spend about

11 Billion a year in round numbers on nuclear security, i.e. the nuclear stockpile nonproliferation and naval reactors, and another 6 Billion a year roughly in environmental management or cleanup of the cold war legacy. So we are a relatively small part of the Department of Energy, but nevertheless in many ways the most visible in the energy technologies.

So we're looking for principles by which we might be able to establish multi-year plans and budgets. One of the things that seems to be very important is to be able to articulate a rationale for why the Department does what it does. Not only does it let us plan more effectively but also provides some protection against interventions by various other players in the budget process about, oh, why don't you go do that. And of course energy technology is one of those fields where everybody's got a favorite. And if you look at the Department's programs, they reflect that to some extent.

We're also of course interested in providing some views about the technical status and potential of various technologies. So, you know, we could drive down the cost of solar by X with a concerted program, or we've pretty well hit the bottom in internal combustion engines.

So we are embarked on a process in that we will produce a document within the next several months

that consists of a framing of the energy challenges, a discussion of the various roles of government, the private sector industry, the national laboratories, universities in transforming the energy system; as I mentioned, roadmaps for technologies, principles for the Department's activities; some discussion of a support for demonstration projects which are a large and often contentious and frankly somewhat inconsistent part of the Department's activities, and then of course the connections between policy and technology.

Here's the timeline for the exercise, and I'll walk you through it just briefly. Back in November, at the end of November, PCAST issued a report from a task force chaired by Ernie Moniz and Maxine Savitz, and what they said was there shall be a -- or they're recommending, of course it's only recommendations, advisory: the government should undertake a quadrennial energy review analogous to the government's quadrennial defense review.

Those of you who know that latter exercise know that it is a four-year process with typically five-year horizons that outlines the nation's defense posture, the force requirements needed to meet the defense challenges, and then an acquisition strategy on a five-year horizon. And that document actually has a lot of credibility as one goes through the budgeting

appropriation authorization processes.

If you look at energy, energy has some fundamental differences from defense, but the energy system is really quite different the way we do government activities. And they thought doing this kind of five-year horizon in an integrated way would be a useful thing.

They also recognized, however, that that would be a massive undertaking. Energy touches probably about ten different cabinet agencies. It necessarily involves the private sector, et cetera, et cetera. And so they said that would be too hard to do, particularly given where we are in this administration's cycle. And so, DOE, you go off and do your own for practice, was their recommendation. We figure -- PCAST figured it will take about six months and you should do it on DOE's activities in energy, primarily technologies.

Then back in January, after thinking about it and some discussions with the folks in the White House, the Secretary asked me to go ahead and try to do this. Discussions with OMB subsequently narrowed the scope down to energy technologies and the policies that might affect their development and demonstration, mostly within the Department of Energy. And so we will not get into such issues as what should the ethanol tariff be or what exactly should the clean energy standard be. However, you

know, the financial arrangements for the support of large demonstrations are perfectly well within our scope.

And I think actually that focusing is a good thing. It will cut the problem down to something that is very manageable and also will necessarily underlay any quadrennial energy review that the government might choose to undertake in the next year or so. So this is not the energy review -- the government has not decided to do that -- but nevertheless is an important foundation for it.

We put our framing document in mid March on the web. I expect you all will have seen it and perhaps had a chance to read it. Public comments went through mid April, as XXX mentioned about 60 of them. They're all up on the website, which one can easily access. The workshops are discipline specific and are meant to be a solicitation of input and comment from diverse stakeholders on each of the strategies. Our goal is to submit by the end of July or beginning of August a document to the White House for approval and then release before the end of the calendar year.

As XXX mentioned, we're trying to run a very public process, in contrast to perhaps other energy exercises in previous administrations and also in contrast to the QDR where the government owns defense, whereas it

is the private sector that owns energy sources.

Here is the larger goal for the exercise, and I thought I would just walk you through the different pieces so you can get a sense of where this meeting today fits in. Let me start first with the energy context. In the framing document, we tried to paint the U.S. energy landscape and the challenges associated with it, predominantly oil security, U.S. competitiveness, and environmental impacts. That discussion naturally leads to a set of six strategies which we've been using to frame the process. There are three strategies on the bottom for transportation and three on the top for stationary keyed more or less to the common Sankey diagram that one sees.

On the transport side, increased vehicle efficiency, starting from the right to left, biomechanic style; second, progressively electrify the fleet, starting with hybridization through plug-in hybrids and then varied vehicles; and then deploy alternative fuels. We're going to need -- beyond electricity, you will need some sort of chemical energy to power heavy-duty transport. Electric airplanes are pretty far in the future if they're there at all, so we're still going to need liquid hydrocarbon. The dominant goal on the transportation side is to reduce oil consumption, not necessarily reduce foreign oil consumption, because those of you who know anything about

the oil business know that there is no such thing as foreign oil. But it's really to reduce crude and decouple from the global oil Market.

On the stationary side, increase building efficiency and industrial efficiency. We had a great workshop in Pittsburgh last week on that. Modernize the grid, which is this discussion. And then in two weeks in Denver the clean electricity discussion. Each of these boxes is a strategy that mixes policy, economics, and technology. We're about the technology, but you're still free to comment on the policies. But in the end, the QTR will be about the technologies in each of those areas.

A second piece of the flow in the exercise are technology assessments. We have inaugurated actually about six weeks ago 14 different technology assessment teams, each led by a DOE person but involving people from the laboratories as well that are meant to produce assessments of various technologies important to energy. All of the usual suspects are there. There are two or three associated with the grid. I've forgotten how many. Three? Three. And we will hear from them this afternoon. They are meant to talk about the status and potential of the technologies, about the roadmaps for improving the technologies, cost milestones, scheduled performers and so on.

As I like to say it, these are not program plans or budgets. They're meant to be kind of one and a half significant figure assessments so that at the end we'll be able to say, you know, do more wind and do less bio fuels or something like that.

Here is what we would like to have in a discussion of each of the technologies. Why is the technology there? Not all technologies will be included. Some might be too mature, others too immature, some might not be material enough. What's the head room in the technology? How much could you imagine it providing in terms of supply or how much efficiency could we get out? In other words, what impact could you imagine it having? What's the current state of play among the actors? Roadmap, what is the DOE history in this set of technologies and what has it actually done?

I started to make myself unwelcome a year and a half ago when I started asking around the DOE, well, what impact have you really had in energy and after 30-some-odd years in the DOE. I'd be interested to hear your answers, those of you who know the Department well. What impacts has the DOE really had in energy?

Policy context barriers, and then some specific things. You know, somebody said wide-bandgap semiconductors for power electrons or something is

important. That's the kind of thing we're looking for in these technology assessments.

Technology assessments happen in the afternoon today. What happens in the morning today is a discussion of the central column in this logic flow, which is, well, who and how do we do these things. I'm interested in a discussion of the various players and their relative roles in making energy transformation happen, private versus government, within the government, and with DOE versus Interior versus whomever. I'm interested in discussion with respect to the grid of the relative potency of the economic, the policy and the technology level.

I saw a study that a crew in California has just put out that says California could get 60 percent greenhouse gas reductions by just deploying existing technologies. And so the development of new technologies there is a second longer range thing, and the most important thing is to get everybody to start to deploy. So how is it here within the grid modernization discussion? And then again lab versus academia versus the private sector.

Ideally if we get all that discussion right we will get a set of principles that would guide the construction of the DOE activity portfolio. So do more

long term, do more short term, don't do demonstrations. I mean, principles like that. I think we're far enough along to realize that there will be no one set of principles applicable for all six boxes, except very general ones. But it would be good to get your sense of what you all think the principles might be for the grid work.

If you then take all three of those strands together, the strategies are what you're trying to do, the portfolio principles, and the technology roadmaps, which depending on your metaphor are either the ingredients that you make the stew from or the palate from which you paint the picture or the basis vectors from which you draw the solution, that should give us a portfolio and a sense of priorities. That is about as far as the QTR goes, down to that second box.

The detailed program plans and budgets are a separate exercise that's going on within the Department for FY 13 now, but nevertheless this process is closely coupled with and strongly informing of that discussion.

So we're interested again this morning on relative roles of players, principles by which we should evaluate and prioritize various technologies, and then the connections of energy technology, innovation, and policy.

We thought it would be interesting for you

to see some of the comments that have come in. They're all up on the web so there's no embarrassment here, or at least no additional embarrassment by putting them up. And here are some that seem to us particularly interesting. William Pickard, from Washington, who I don't know, says in this present world energy is the commodity of commodities, and Congress should do whatever is constitutionally permissible to make it flow. The logjam on energy transmission must be removed, assuring that safety of that transmission is a realistic goal.

That sounds like an eminently sensible comment to me. On the other hand, I'm interested that energy is equated with the grid here, and that's sort of one of the characteristics we've seen going around talking to lots of people, that there tend to be rather narrow views of what energy is: energy is the grid, it's the fuel system, it's all of the end uses thereof and the providers of. And so good to have a more synoptic view as we go into these discussions.

UTC Power says policies should encourage utilities to deploy distributed generation to supply and support, supplement the central grid. So they'd like to see that.

Some of you will know or have read the books of Vaclav Smil, characteristically blunt in a set of

comments: Compared to Europe the country has no interregional interconnections and the grid looks quasi-medieval.

Other experts in this Near Zero discussion saw the task of modernizing the grid as one of deployment and development and said what -- why is DOE investing in technology at all there.

And then B&W said DOE should develop roadmaps and set guidance on combining intermittent renewables with backups or storage. Wind and solar PV providers continue to improve reliability but currently have no incentive to deal with the intermittency problem.

So those are some of the flavors of what we've heard about the grid.

To prime you for the discussion we're about to get started in, here are some things we heard from the three other workshops we've held so far. Somewhat surprising in many ways. The alternative fuels workshop, the value proposition of the Department is predominantly in technology assessment, not technology invention. That's pretty interesting. Many people working in the Department believe it's our job to invent the technologies that will foster the clean energy revolution.

A second thing we heard at the fuels was really interesting. If you read the framing document we

have been talking about U.S. competitiveness in energy largely as the ability to innovate, to develop new energy products, and then go manufacture them and sell them to the rest of the world. What some folks at this workshop said was, you know, you got it a little bit backward. Inexpensive energy is what is driving U.S. competitiveness and cited, for example, the return of chemical industries to the U.S. and manufacturing because of the cheap gas that we have right now. So that was an interesting take on the situation.

In the vehicles workshop, efficiency and electrification, a lot of uncertainty around consumer acceptance of new technologies, particularly the electrification, but also the fuels, whether it's hydrogen or CNG, and we're entering a decade of experimentation. Other people noted that we're already well into a decade of experimentation and it should be soon time to make some selections.

The disconnect between infrastructure and vehicles here was important and a major topic of discussion. Right now the infrastructure and vehicles are owned by disconnected sets of folks, the oil companies versus the vehicle manufacturers and consumers. Obviously they have to play together. If you think about going to alternatives, whether it's electricity or a hydrogen or

natural gas, you've got to get both of those pieces moving together, and that is again a real social challenge as much as it is a technology challenge. And what is DOE's role here? Not clear.

Public-private partnerships, very important here because the industry is quite mature.

Then on a technical level with respect to the electric vehicles, there's disagreement on the need for fast charging. One person said, you know, if it takes me more than five minutes to charge up my battery, this is a nonstarter for me. And then other people said no, no, you don't understand. You don't have to charge it all the way, and anyway you can go get a couple cups of coffee while it's charging. So that kind of sociological discussion is very interesting. And of course very important for this workshop is the ability of the grid to handle growing electrification on the transport system.

In the buildings workshop what came through was that we really need better data. We're flying blind on how efficiency is used in homes, in industry, and we need better models informed by that data. You would think with modern technology you could just scatter sensors everywhere and collect data, but in fact the data sets we have are pretty sparse. So there's a wonderful opportunity here to go out and get some real data, which

as I've discovered in energy discussions really changes the tone of the conversation.

Skilled workforce matters, both at the installer level but also at the sort of engineer designer level, but again not clear what DOE's role is given the way it is presently structured.

Okay. Let me then turn to what I'd like to have us focus on this afternoon -- this morning. Let me put up some cross-cutting questions. The grid has got many different technologies and applications. How do we balance the depth versus the breadth of our investment? Take a few things and push hard or really spread our investments around?

As I've mentioned already, nontechnical barriers seem at least as significant as the technology ones, and how do we balance our efforts in those. And if so, what do we do about the nontechnical barriers?

What about different time scales to impact, should we be working on things that can have an impact in five to ten years? At least in the political sphere the energy challenges are important and urgent, et cetera, et cetera. Does urgent mean we can wait years to see the impact of a technology, or do we really need to be working on a shorter time frame?

And then with respect to this first

question, the DOE has been repeatedly noted as being a technology agency and hence focussing more on widgets than on systems. The grid of course is the quintessential system, and are we doing enough at a system level rather than synchrophasors or inventing superconducting transmission cables or pick your favorites. So the system view versus the widget view.

Another question, are infrastructure investments keeping pace with our investments in new generation and what the end users are doing? What role should DOE play in shaping the infrastructure investments?

The grid, we've got several different ways we can go about tackling it: large-scale deployment of clean generation, the smart grid, energy storage. What about the phasing of all work in those three different areas? Do we need to have the storage in place before we can ramp up on the renewables, for example, or the other way around? How does that work? Should we think about timing our efforts differently?

What are the prospects for significant new transmission assets nationally? Again, as I've learned, this is not so much about technology as about politics and economics. Where would you put them optimally? What would have to happen to alter your opinion on the topic? And if there is to be no new transmission for the

foreseeable future, how should our portfolio of activities change?

Penultimate bullet, what are the rules? Again, we keep looking for rules to help us put together the portfolio or the program and hence the budget. Does every technology deserve to be in there? When does a technology get to be included? When does it exit and we say, hey, we've done it already, it's now commercial, you don't need government funding anymore to keep it going?

What metrics should we use to measure grid technology? The grid is one of the harder things to measure, at least from where I sit. I would like to hear your own opinions. You know, if it's clean electricity, I can measure emissions, cost of electricity, ability to ramp up and ramp down, pretty quantifiable things. Similarly in vehicles, cost per megajoule of fuel, miles per gallon, et cetera. I'm having a hard time with -- well, actually, we are having a hard time with the grid. So your help there for metrics would be useful.

And then finally, what does the DOE do for you? Where have you seen the benefit of our work in the power system?

So those are the kinds of questions I would like us to focus in on this morning. As I said, we'll get to the technologies this afternoon.

So we're going to try to address some of those questions first in a panel and then in plenary and breakout discussions. So let me ask XXX, XXX, and XXX to come up and take a seat, and we will get started.

While they're doing that, does anyone have a question or comment on what I've tried to lay out so far?

I guess there are microphones there. So let's just go down the row, you can remind people of who you are and maybe a little bit more about your own background.

XXX: Well, thank you, Under Secretary Koonin. It's a pleasure to be here.

I'm XXX, with NIST, and I work on standards for the grid and mostly with DOE, of course. And, you know, my role in the standards causes me to think a great deal about the infrastructure aspects about what we're doing, because standards really are key to embedding new technologies into an infrastructure.

The questions that were posed really triggered a number of thoughts that I'd like to share. Well, looking at the big picture, one of the things that distinguishes the grid and the energy system in the U.S. from some other countries is the degree of fragmentation that we have. We have over -- well over 3,000 electric utilities. Many of them are very small entities. They're

regulated in different ways. And as I contrast other parts of the world, China is a totally different system where things are much more centrally planned. We just don't have that in the U.S. So I think one of the important roles that DOE needs to play is to provide kind of the glue that allows this very fragmented system to work in a somewhat more coordinated way, addressing key national challenges.

As I think about the kinds of things that DOE could be addressing, the dichotomy of widgets versus systems, I think there needs to be a dual focus. Certainly there are key technologies in which we really need some break-throughs in order to -- for them to be viable, thinking here of things like storage and batteries, where we have vehicles and we really need to get dramatic reductions in cost and fundamental science and engineering. Technology development is near and dear in DOE's investment and is really important.

But I think that many of the technologies that we're dealing with in modernizing the grid have been around for a long time, and barriers to using them have been more deployment related. Technologies have been demonstrated in laboratories or small-scale pilots, but you don't really get the benefits until they're widely deployed. I'm thinking of something like phasor

measurement units where the technology has been around for about 20 years, but until you actually deploy a lot of them and have the ability and infrastructure to collect data, you don't get the value. So I think that looking at one of the key infrastructure challenges were some coordination, investment, and leadership. These are areas where DOE can really have a big impact.

So I think I'll stop there and turn it over to our next panelist.

XXX: So we have a choice. We can -- why don't we go down the panel, and then we can come back.

XXX.

XXX: Well, good morning. And I guess as the Arizonan on the panel I want to welcome you, XXX and everyone here, to the great state of Arizona and the solar energy capital of the world. And we hope -- the solar energy research capital of the world, too. But thank you all for being here and picking Arizona as the place for this important workshop.

I'm XXX. I am a former Arizona Corporation Commissioner. I had the great joy of serving the people, the 7 million people of Arizona, as one of their public utilities commissioners. I served as the chairman of the commission for two years, from 2008 to 2010. During that time had the, you know, absolute honor

of helping to coauthor Arizona's renewable energy standard, which has one of the most ambitious distributed generation carve-outs contained within it, and also helping to coauthor the nation's most ambitious energy efficiency standard at 22 percent by 2020. So we believe in Arizona that we have one of the most decentralized systems of provisioning energy, or at least moving toward that, and so we think we have a lot to offer and we're pleased to be here to talk about these critical issues.

And I don't want to go through all my comments, but I was so intrigued, XXX, by your opening comments when you said we're here to tell the story about the Department. And I hope -- that's going to be a theme of my comments, because I think that is so very important. We can have all the meetings that we want of great experts like we have assembled in this room, but if we don't have the support of the people of this country for what we're doing, if we don't inspire the people of this country with what the DOE is spending Billions of dollars on, if we don't have an immediate impact on our nation's most important and critical energy problems, then all of these meetings will be for not. And, you know, we are at a -- I personally think, as a former regulator and now a law professor -- I forgot to say law professor at the Sandra Day O'Connor College of Law at Arizona State

University -- I personally truly believe that we are at a pivotal point in our nation's energy history at a time when our economy is still struggling, when -- well, I know Americans truly believe we need to move toward a clean energy economy -- it may not be top of mind for everybody because they're worried about pocketbook issues -- and at a time when unfortunately energy efficiency renewables, the grid, smart grid have become politicized in a way that I think is not good for our country. And so we need to find ways to not just advance technology but also deploy technology in a way that it engages Americans and tells the great story of agencies like the DOE, the EPA, and states that have been taking the lead.

XXX: Thanks.

XXX: Thanks, Under Secretary Koonin. I appreciate the invitation.

I'm XXX, with the Electric Power Research Institute. Good to be here in Phoenix.

XXX, is anyone left at Arizona State? It seems like you guys -- is anyone guarding the fort?

XXX: Not right now anyway.

XXX: They're all here. That's great. Pleasure to be here.

I'm in charge of our overall research in the grid, all the way from the generator to the washing

machine. And it is a critical area facing us right now. My own background, I come from more the smart grid and distribution side of EPRI. I've been there since 2003. Before that with both vendors and consultants in the energy field, working with EPRI and DOE over many years. And it is a very exciting time.

I work with XXX and XXX on the smart grid interoperability panel, and I think that, you know, one thing right off the top of the list for DOE is helping with the foundation in terms of the architecture and the standards for making all this technology work together. Because we work on the individual technologies and the first question we're going to get to in terms of the depth versus the breadth of the investment, we really do need to understand how it all plugs together. And cyber security issues come into play there right at the top of the list in the industry, where it really all revolves around how we're going to make this architecture work with distributed controls that need to work together and each one of these technologies that we're dealing with having its own controls and need to plug into that architecture. So I think that's a very important aspect that we'll keep in mind as we talk today.

XXX: Good. Thank you.

I've got a few questions now of my own

written down, but I'm going to save them if there's a gap in the discussion over the next bit. So I'm just going to throw the floor open for comments of the panel, questions, questions the panel might have of one another is always good. Common tactic on thesis committees, right? Get the committee fighting with itself.

So the floor is open for anyone.

XXX: XXX, of Beacon Power.

XXX: There's a mike in the aisle here if you want to use that.

XXX: Thanks. Can you hear me now?

XXX: No better. Use your big voice.

XXX: How about now?

XXX, you mentioned the one item that I think is very, very important, the whole notion of dispersement or deployment of the technology. This is a very hard phase of the whole technology invention and development and then eventually trying to get it to take root from a commercialization standpoint. You mentioned that our system from a regulatory standpoint is -- the term is vulcanized. You didn't use that terminology, but we've all heard it. And it's extraordinarily difficult to make that jump from eureka, I've got something that really works well, you know, to getting it into the system.

And even though, you know, classically DOE's

role has been let's focus on the widget side and maybe the system of widgets, to a degree you can warp -- more work needs to be placed on the deployment side. You've done that -- to a large degree you have put kinetic energy storage on the map, going from laboratory scale to demonstration to full scale and deployment. And it works extremely well, but it's not quite done yet. The supply chain is still really not there. So you kind of have to work on that back end harder. Don't know how to do it, but that's the problem.

XXX: If I could, you know, respond to that, I think that there are a couple of things that I've observed are really barriers to deploying new technologies. One is that most of the R&D, when you get beyond the science, a lot of that is funded by DOE. But when you get to the R&D of the widgets, if you will, a lot of that is being done by industry, by the suppliers. The electric utilities for the most part -- I can think of a few exceptions -- very large utilities, but again we have 3,000 utilities, are really not incented to spend a lot on R&D. In fact, they've been driven by the regulatory system that we have to reduce R&D expenditures. So what you have are new technologies that need to be integrated, you know, proven in to a grid. And that takes engineering talent, and the suppliers can't do that. The utilities

have to do the integration and prove this in. And if they don't have the funds and the human resources to do that, it's not going to happen.

So the reason they don't have funds is that regulators really have a premium on keeping rates low and do not see this linkage between technology and ultimate end-user benefit. So we really need a way for government to kind of, you know, put more emphasis both on the getting the regulatory system to appreciate the need for the R&D investment by the utilities as well as building a capability, human resources as well as the financial means, to get this deployed and the entities to deploy these technologies. So I think that's an area in which DOE can really, you know, play a role in making this very fragmented system operate a little bit more like it's a coordinated system with a longer goal plan.

XXX: I'd like to -- your thoughts stimulate a comment relative to the fossil fuel industry. There are many folks in Washington, but not all, that think that the Department shouldn't be in fossil fuel research at all because, after all, there's plenty of money there at the moment. And if they need the technology, then they will develop it.

You might try to make the same argument in the grid sector. I scribbled a little bit. Say

Billion a year is the scale of grid business, something like that, at a penny a kilowatt hour times 4,000 terawatt hours a year. There's plenty of money there. But it is this regulated and fragmented nature of the grid that makes it different and enhances the government's role.

XXX: Right. And, you know, if you have a utility that's able to prove it in technology, if that -- if it were a pilot in one entity -- you know, I think back to early in my career 30 years ago at AT&T where because it was one system we could prove something in at one place and then deploy it to scale. But with 3,000 utilities, each of them acting independently and really an unwillingness to -- well, inability to see the results of what the utility is doing or to really believe in it, it just doesn't happen.

XXX: Under Secretary Koonin, I'd like to comment on one reXXX you alluded to and two that XXX raised. You mentioned one comment received about the importance of low-cost energy. That almost got it right. It's actually low-cost energy services. By that I mean it's not just that we pay less for natural gas, but it's the arrangement by which we use the natural gas and emit more pollution, more POx, or we have an industrial process that has many two-step -- too many steps in the process of producing its goods. So to the

extent we integrate efficiency in a way that allows an industrial firm to drop out a step in the process, something that reduces energy services to the extent we're more efficient, we don't have as much in the way of POx or carbon or other conventional pollutants to it. So the total cost of energy services absolutely has to decline not from tomorrow's projected dollars but from today's dollars. I don't think people understand that critical role.

But then what XXX said is absolutely right. We've got to tell the story, and we do not have a fundamental appreciation in this country of how energy is being (inaudible). And more critically, notwithstanding -- and I will challenge the PNNL folks. Your famous spaghetti diagram suggests that we're maybe about percent efficient in the way we use energy. In fact, if you look at the numbers from my colleague XXX, many consider him to be the father -- godfather of industrial ecology, our economy is at best 13 to 14 percent energy efficient with the way we convert energy into useful work in this economy. That means we're wasting 87 percent of all the energy we throw at the problem.

The grid moved from about 2 and a half percent efficiency in 1900 to about 32 percent efficiency

in 1960. I was in junior high school. Ike was in the White House. And we haven't fundamentally gotten any better with the grid efficiency since the 1960s. What we waste in the production of electricity because of the grid is more than Japan uses to power its entire economy. It's that huge. We need to be thinking about not only modernization but substantial system efficiency improvements at large. We are at a critical imperative in our economy and we need to do a better job of getting the right kind of information for people to know how that affects or constrains our prosperity as an economy.

XXX: Comments?

XXX: If I could just jump in and respond to that and also something XXX said. You know, indeed we have thousands of utilities and, you know, at least 50 regulatory bodies deciding these issues. But I would argue -- and it is tough for regulators to accept new technologies, to allow cost recovery of truly new technologies. But I would argue that, you know, there are things that regulators could clearly use some help from DOE on.

As a former regulator, I can say the three things that I think DOE could have an immediate impact on are helping to bring down the cost of solar and other renewables, which you're doing with the Dollar a Watt

program. And it's a very focused, very tangible, visceral thing that I think people can get their minds around.

Bringing down or helping in modernizing the transmission grid. We do not have a transmission grid in this country -- and those who will get to this about infrastructure -- that is designed to meet the needs of moving renewables throughout the west. So whether that's new transmission technologies and the kind of work that XXX is doing at ASU or to make the transmission system more efficient and to use it for storage purposes or developing or helping us get that transmission deployed is something DOE can do.

Helping also in preparing utilities for what I call cascading natural deregulation, which is what I think is going to happen when DOE is effective in getting to grid parity, helping us get to grid parity, energy efficiency is widely available and we have storage commercialized.

So what I think DOE could do in helping regulators along is to get these existing -- help us get these existing technologies deployed. And I don't know. Let's see if DOE can put together something like a scientific seal team 6 that is -- not to be too colorful about it, but that is designed to attack the nation's most critical energy issues. Right? So we know what those

issues are. It's our transmission system, it's the cost of renewables, it's smart grid to some degree. And actually attack those ways in a way that are visceral and understandable by the public at large so we can bring them into this discussion.

XXX: So, XXX, you know, I think I agree with everything you said except to note that there's a whole other half of the system called transportation that you didn't say anything about. Many people would say that's the most important thing these days.

XXX: It could be.

XXX: So, again, it's a great issue of how you balance between those things.

XXX: True.

XXX: I'll make a comment about it. I think that the role of DOE in helping the regulators is absolutely critical. And there's a couple of areas that -- associated with every technology research project that we do and demonstration that can help, and that is from a modeling point of view being able to take these technologies and plug them into the tools that the industry uses to evaluate how they can improve the grid performance, and then take that and make sure that we have standard approaches for evaluating the economic benefits.

I think we've done a good job of that in the

demonstration and stimulus projects, laying down a cost-benefit methodology. But I think it needs to be an integral part of basically every technology research that we do, how can a regulator look at that technology and say whether they would want to encourage that to be deployed on the transmission or the distribution grid with a methodology that gets applied across all 50 states, not a California methodology, not a Texas methodology. And DOE can help with that.

I think we're starting down that path. But if we make it an integral part of what we do when we're looking at kinetic energy, making sure that we have models for these devices that plug into our standard system analysis tools and then models for evaluating the economics would be very beneficial.

XXX: I was just going to add to that. I think the other thing that can help in this area is that, you know, when I think about everything that DOE is doing and everything that the national labs are doing and there's just some spectacular research being done at our universities, our national labs funded by DOE and the private sector, there's not a lot of communication it seems to me between these different sectors. I mean, when I was a regulator, I only started to learn what DOE was doing when my utility started to apply for some of that

money. And so, you know -- and that's really sort of the basic -- the average regulator, that's how they know DOE. And there's even less knowledge amongst regulators I think about what's going on in the national labs and maybe sometimes national labs don't know about the great work happening at universities. So if there's a way for DOE to make sure that this research gets known, distributed, and doesn't land on a shelf someplace. That's why I'm a big fan of demonstration projects and applied research, actionable research that gets distributed into the public consciousness.

XXX: We are making the big push at the Secretary's behest starting already two years ago. At least the technology transfer out of the laboratories has been enforced.

XXX: I know this is an important engagement process. I'm not officially an invitee; I'm a volunteer from ASU. I'm a first-year Ph.D. student, stakeholder for sustainability engagement with a background in CSEE, have an MBA, and have worked in mostly energy efficiency throughout the decade.

I'd like to address what was just said about engagement in a broader sense. I think it's really worth focusing on the nontechnical barriers. You mentioned potentially percent reduction in California using

existing technology. That's nontrivial. I think there is an opportunity not only to transfer technology, but if you look at this room it's a lot of men. It's a lot of EEs. And there are opportunities to have people, for example, who are women, who are oriented not only to designing and creating things but to integrating things, to bridging heterogenous systems. Technology and standards are absolutely vital at the vanguard.

There are other organizations like the military which are more habitually mission oriented and may from a policy perspective have more of a sense of how do we take the best of the leading edge of what's over here, here, and here, how do we simultaneously encourage multiple strands of development, of communication towards specific kinds of goals. It's a different orientation than necessarily basic science or basic research. It's more towards the getting it out the door kind of conversation amongst broader publics. I guess that was about it. Okay.

There's also thinking of it as a market rather than only a set of technologies in terms of the maturity. And as much as there's leadership and coordination, also listening, soliciting entrepreneurs who could potentially -- and even Europeans, who describe our grid as medieval, could potentially bring a lot to these

kinds of conversations. Thank you.

XXX: Thank you.

XXX: I would like to continue what XXX started with the elective R&D support in -- I don't think that works, I will speak up, elective R&D in the grid specific area. We started this whole effort of optimization of smart grid, but it was somewhat ad hoc, start at the bottom up. And the lack of the view of the architecture of the future grid I think is extremely important. If you ask the people there are probably not going to be as many opinions what the grid will look like in 10, 15 years as people here. And I think we need a specific focus support in that kind of initiative to see what kind of grid we expect in 10, 15 years, because our planning departments today are planning grid in 10 or 15 years. We are still building the grid the same way as we built it three, four years ago. There's no change in their view and an idea how the grid is going to look like.

We already brought up the issue of centralized versus decentralized. Do you want to build this huge amount of transmission to move the wind around versus building more a micro grid and distribution, generation, and building a more decentralized architecture. Because it could be a lot more resilient.

In fact, I don't agree with European.

Europe is in fact moving to decentralized a lot faster than we do because of the geographical and political structure. They are building micro grids all over, and micro has become the alternative for the grid.

We also have to realize it's another issue that today's R&D at universities kind of expect a very short and quick return. So universities are kind of forced to work on some very short-term research rather than fundamental research. We don't have a fundamental research in grid, specifically in grid area, and that's where I think the government should put the effort there.

And we also have to realize that if we are trying to decarbonize our industry it's not necessarily the most economic way of -- at least in the nearest , years, electricity is not going to be probably less expensive. I think XXX touched on this. If the urbanization is the main reason, not the cost of the industry, we have to realize and start building the system based on that. Thank you.

XXX: How do I know -- I'll ask a more general question. How do I know when I've got a better grid? I look at the grid today, I look at the grid eight years ago or eight years in the future in one of these hypothetical scenarios, how do I know it's better? What do I measure to know that it's better?

XXX: I think there are a number of factors. One of it's -- one primary factor is performance.

XXX: What does that mean?

XXX: Reliability. How many blackouts have you had? How many disruptions have you had?

XXX: I can sympathize with that. I live in southern Maryland.

XXX: How does the quality of your service in terms of vortex, frequency tolerances. I think cost eventually, how good is your service provider in maintaining cost and meeting all these other requirements. So I think there are very good metrics there.

XXX: The quantitative objective matrix you can --

XXX: So let me give the regulator's response to XXX's professorial researcher's response, which I think is exactly right. And though some of the things he mentioned matters to regulators too and policy makers, but my answer to that question, Under Secretary, would be we know we have a bad grid when we have a grid that doesn't tell consumers about their energy usage and is not responsive to consumers in terms of using smart meters to provide information on a real-time basis to

consumers and is the vast reality throughout most of America right now.

We know we have a bad grid when in the state of Arizona we have cited, permitted and approved five utility scale solar projects that are now stranded in the desert of Arizona because they can't get to the market in California. That's a problem. And our utilities are not solving that problem right now.

Our utilities are doing a fantastic job of creating safe, reliable transmission and distribution systems within their own load pockets and within their own states. And so I would say that from a policy standpoint it's a little bit larger -- it's everything XXX said, but it's also something larger. And I think we can measure it in those ways.

XXX: If I could just add one metric we don't talk about much is asset utilization. The grid operates at about 50 percent of capacity. I mean, in any other industry 50 percent capacity would be a prescription for bankruptcy. So the question is could we be doing a lot better.

The other observation I have is if you looked at these kinds of metrics for the telephone system years ago you would say it operates great. Five s reliability, very low cost. Yet look what's happened.

We've gone through just unbelievable transformation, and to some degree we traded off a different set of benefits for functionality over reliability, maybe a slightly higher cost.

So the question is are there similar sort of radical transformations that could be possible with the grid. Micro grids, as was stated, could lead to a much more resilient design, which you won't pick up necessarily reliability, the once-in-a-century sort of disaster, but you would have a much more resilient infrastructure. We don't even know. The question is whether we can get there until we have the research and some concept about whether these architectures are even feasible to operate.

XXX: And then what is the cost vis-a-vis the benefits, so the same kind of counters.

XXX: I wanted to ask two questions. One is if the panelists could address the fact that the cost of electricity is kind of skewed, and then what about the fact that Arizona's natural gas plants are only operating at total like 25 percent capacity factor.

XXX: Yeah. Well, XXX, let me answer the second question first, because I'm not sure I quite understood the first one.

But, yeah. I mean, I would say that is another indication that our transmission grid is a bad

transmission grid right now in the sense that -- or is failing us. We have cited -- we have some fairly cheap gas that is cited, been cited in the state of Arizona, and, you know, between 25 and 30 percent of it gets used on a regular basis. And, you know, a lot of that gas needs to get to market, and it's just not.

And I'm not sure of the first part.

XXX: Subsidies, uncounted cost of electricity, water.

XXX: The externalities issue, of course. I mean, when we talk about the cost, we are not of course in most states yet -- although Arizona is moving toward this, California has already done it -- we're not pricing into the cost of electricity externalities, and that needs to be done.

XXX: If I might add, back to XXX's comment, 50 percent capacity utilization at 32 percent efficiency, essentially unchanged since 1960. That's a dynamite metric if we can pull that into discussion.

XXX: The 32 percent is the chemical energy to --

XXX: The efficiency of combustion to delivery to the industry.

XXX: My understanding, I'd be

interested if someone in the room knows, is the T&D losses themselves are at the few percent level, 6, 7.

XXX: Something like that.

XXX: Correct.

XXX: That's about the right number.

If I may just make one comment on the metrics before we go on to the next question. I think that clearly it needs to go beyond our traditional reliability and security metrics, and I think one topic that's very high on the list is a metric for flexibility. We need some kind of metric that puts the value on storage, micro grids, things like this that allow us to integrate more renewables and variable generation. And once we agree on a standard way of putting a value on whatever that metric is, which we just need to figure out, if we can make some progress with that.

One thing to keep in mind with, you know, natural gas plants is that as we integrate more wind and a lot of cases we're going to just need more natural gas plants as well and they're not going to operate. And that's what we want. We want to use the wind.

In Ireland we put in a natural gas plant for every megawatt we put in, we put a megawatt of natural gas in. But we don't want to run it, but it has to be there.

That's part of making sure that the grid is secure, because they go for three, four days without wind and not -- there's no storage that's going to take care of that need. So, you know, you have to look at the security, flexibility, and overall economics of different generation.

XXX: My name is XXX and with the New York ISO, but previously I was head of the office of electricity at the New York PSE. And for the last three years I've been head of the energy policy office in New York City, working with Mayor Bloomberg.

And I wanted to go back to something XXX said, and I agree completely, and that's about helping DOE with certain technology areas. And you mentioned the solar PV. And in New York City -- and I'm going to use New York City as an example -- we had great visions about things we wanted to do and willing to put a lot of money into certain projects, and we were flying by the seat of our pants in many cases in terms of the technologies. And there are two that I just want to mention that I think are great potential.

Offshore wind, especially for the northeast. We see tremendous potential for offshore wind formed off the coast of New York City, and you've seen that being discussed and proposed up and down the east coast. But we

really could use some help, especially the cities could use some help, states in terms of technologies, what works, what doesn't work. Right now a lot of these local governments are facing a lot of risk in how they approach this and what they -- basically what risk they're willing to absorb.

Another area, another technology that just has incredible potential for the northeast, and also interacting with the grid, more advanced systems for allowing buildings, especially New York City, very large commercial buildings to interact with the grid on a real-time basis to actually participate in wholesale power Markets. Right now we have been limited in terms of learning what there is to know from a few select vendors of technologies, and it's an area that I think is a big payoff with DOE assisting the states, assisting cities in how they approach that, what potentially could be a very large Market.

XXX: So just know what to do and what the costs might be and things of that sort, knowing what works?

XXX: Here is the range of technology. If you are going to approach this, here's the way, what you should consider in request for proposals. Not steering towards any particular vendor, but I think it

would provide a lot of comfort to cities, large cities wanting to move forward more quickly.

XXX: That's interesting.

XXX: Again, what that does, the added benefit of that is that you have a city involved and city politicians and city residents who see what they're doing and can become involved in these demonstration projects.

And same thing is happening in Phoenix. DOE has funded the Energize Phoenix Project, which is a joint protect between ASU, City of Phoenix and APS, and we are going to go into the homes of thousands of Arizona residents along the light rail corridor and make their homes more energy efficient. And we are going to hopefully inspire their interest in this, inspire their support of DOE, inspire their support of the commission here and APS will get some benefit from that. But that's really important, to engage with people with these -- with the research funding that DOE is providing.

XXX: One of the challenges, we've worked so hard to make the infrastructure invisible for the last hundred years --

XXX: Right. I'm saying bring it out to the front.

XXX: What's the story from Hawaii?

XXX: Aloha. So the problem we

bump into is we can stack up objective benefits all day long, energy security, for us it's cost savings, greenhouse gas reduction, all that. And we can go out and push all these objective benefits, but we always run into the subjective part of it's ugly, I don't like it. It offends some sense of place or religion somewhere along the line. And so it seems to me that energy is always kind of running in third or fourth place in terms of our priorities.

So, you know, national defense is right up there at the top. You know, you want to get something done, put a national defense reason behind it, boom, it's probably going to get done. But when it comes to energy issues, we're way down the chain in terms of priorities.

XXX: Except when the price of gasoline is high.

XXX: Well, yeah.

So my question from a regulatory standpoint and legal standpoint and to the DOE, how do we move energy up in the scale of priorities of this is an economic benefit. You know, we can stack up all these objective benefits, but when we get to the community level we're going to get into this fight of I don't want to look at a power line. I don't want to look at a windmill. This historic building can't have a solar panel on its roof

even though it houses this entire government agency, so we can't have any energy efficiency on this building. How do we, you know -- we keep losing out to these issues. How do we get over that?

So can the DOE at some sort of, you know, federal level go into the Congress and say, okay, we're no longer second to the Department of the Interior. We're no longer second to --

XXX: Defense?

XXX: -- all these other folks. We're moving up in the chain, because there's -- these are the issues we're facing.

XXX: I don't think it's for us to say in the end. It's for Congress to decide. Again, in the days of high gasoline prices, you don't have to work very hard to make that case. The problem is it doesn't quite spill over to power, because gasoline is about gasoline. But I don't know. I would be interested to hear people's thoughts of how one elevates energy issues in the public agenda.

XXX: Can I make a comment here?

XXX: Speak up.

XXX: Okay. XXX, from IBM Research. Okay. I have a comment about DOE's role here. I think DOE's role should be more take leadership in terms

of how to come up with innovate -- can you hear me? -- innovative regulations to encourage the system -- to encourage potential partnership into energy space.

As a researcher, I have a very specific example here. Right now people are talking with EV, electrification, right? Say, oh, yes, we need faster charging because, as people mentioned, like more than five minutes charging I am not going to buy it so which means we need to have investment in this faster charging technology. But the thing to think about it is auto parts, right? Why do we need fast-charging battery?

For me to drive the car I don't need battery. What I need is electricity. Right? I have different story here. So when I was a child in China, okay, like when we go to the stores to buy beer, at that time the bottle is very precious because hard to make so you reuse it. So now we go to the store to buy beer, you have to bring back the bottle you bought before to get a new beer. But do I care? No. I care content, the beer, not the bottle.

The same thing for EV. Why every EV need to have a battery need to be fast charged? All I need is the thing really for electricity for the battery. So if the DOE have such kind of a regulation, saying, okay, every EV on the road in the future, right, you don't -- you have to

have a way to plug in the new battery. So for me to buy the EV, I don't have to buy the battery. All I need is something I can replace.

So in the dashboard I say, okay, now my car is going to be free in less than half an hour. I just go to nearby station, okay, unplug my charge, put back the new one. I pay for the electricity I consume. Right? I don't have to say, oh, why I need to pay the battery technology itself. Whatever the battery's technology cost will be amortized by the energy I consume.

But that needs the regulation to say, okay, now every EV manufacturer need to provide such a hood to have a replacement battery. The second, every charging station need to have such capability to charge all the batteries people drop off, and then people can come pick it up.

XXX: So this is the model that Better Place, for example, uses. It's not unheard of. If you do a careful technical economic analysis of that relative to alternatives, it's not an obvious win.

XXX: Such things you cannot hear -- other people cannot do. But the DOE or other government agency, right, puts such things in place, entrepreneurship will come to play. Okay. How do I design this battery, how do I make -- design my EV so that the hardware -- even

have a small battery and with a replacement, how they're optimizing. And then every charging station can say, okay, how many batteries I can need and how do I charge the systems. So all kinds of things can happen. That needs the government involvement.

XXX: So there are other people who say the government should not pick winners and losers. I think we have to somehow carefully navigate that.

XXX: There's no need for you to pick a winner or loser. You just put infrastructure, put the regulations, and it causes people to innovate. I think that's the role DOE should play.

XXX: Thank you.

XXX: XXX, University of Washington.

I think on the same lines as the previous comment, it's really a question of getting the utilities to innovate. And I think there the main issue is really a regulatory one. Because all utilities are very, very rational organizations. They know they are really dealing with the -- as XXX pointed out, it's the reliability and economics, the grid and the fear, or the fear of the grid. And they are very, very good at balancing that, and they have been doing it very well for the last 50 years. They don't really have any incentive to change the way they do

it at this point.

Now, if somehow, you know, you challenge them to come up with a creative solution, because they have the people who know how to do it --

XXX: So to change the status quo, the regulatory, the incentives if you like, one has got to have sufficient national motivation to do it. We come back again to the analogies with the defense or public health and so on.

XXX: It's not just national motivation. Has to be the motivation for each organization to innovate. Like in the private sector, you know, if you don't innovate, you're dead. Doesn't happen.

XXX: Privatize energy?

XXX: If I could just quickly respond to that. I certainly agree with that and -- but I would say that states like mine are pushing our utilities. And, you know, an amazing thing is happening on the way to meeting the standards that we've set, at least for our investor-owned utilities, which is that they are increasingly making it a part of their culture and they are responding and they are starting to innovate and they are starting to branch out.

And, you know, when you listen to APS's earnings call, which I'm a little weird, I do that, I

listen to their earnings calls religiously, the funny thing you notice is you know what they talk about on their earnings calls? How much solar they get to rate base because of what the commission is allowing them to do. So when utilities understand that they can make money off of this -- and I think that's very important; it is a regulatory issue -- they'll move forward.

And, again, I think there's a role for DOE to play in basing these demonstration projects at utilities and especially at utilities that are operating in states with very aggressive state-set requirements like Arizona. Because you get to see some efficiencies and synergies I think there where utilities are starting to move in that direction, and then they can get some extra boost from DOE and from DOE funding.

XXX: I think you see that in areas where individual states can make a big difference in the incentives for utilities who are making big strides already. Energy efficiency is one of those where a state can kind of make the rules and utilities can implement programs to take advantage of those and innovate within those rules. Removable portfolio standards is another one.

In areas that involve intrastate, which is the transmission grid, much more confusing and opportunity

for DOE to develop economics and models to help encourage the same kinds of incentives that cut across multiple states. And I think XXX alluded to that when talking about how they can't get the power to California.

XXX: XXX, with USC.

I think it was mentioned this question about understanding widgets versus systems, and I do think there is a key role from DOE. I guess the question to DOE would be if you are thinking about the grid that you're going to have in the future, upstream of that, at least for the U.S. -- in this sense it's quite a bit different than Europe -- what do you do with its connection to the natural resources? Coal and gas in particular. The U.S. has vastly more resources than Europe does. So how does that get accounted for as you modernize your grid?

And the other question I would have is because of the diversity in the United States, just to be a contrarian for a moment, do you need a national grid? Or do you optimize around regional resources and regional economies?

XXX: Those are two great questions. Let me put a rider on the first one, maybe just a bit sharper. Many people believe natural gas is going to stay cheap in the future.

XXX: Unlimited $5 gas.

XXX: Right. So how does that change our thinking about the grid?

XXX: Because it clearly, as big as it is and as basic, as well developed as the gas infrastructure is in the United States, it in a sense can put a ceiling on the price of any other substituted technology.

XXX: Anybody want to comment on the answer to either of those questions? Gas and national grid.

XXX: Transmission is also cheap if you are allowed to build it, and it allows -- we have an extreme amount of diversity in the country and inequality in the prices of electricity that, you know, could start to be resolved just with transmission. Natural gas plays into that in terms of where the natural gas resources are. You can get it -- get that energy through the road. But also natural gas is probably the best balancing resource for wind as well. But it depends on transmission.

XXX: Totally agree with that. And, you know, we know that there are two transmission lines that basically need to get built between Arizona and California which would solve a tremendous bottleneck problem that we have, and they're not being built by our

utilities for whatever reason. And it has to do with some partial California issues, partially Arizona. But that's tremendously important.

XXX: I'm not sure how DOE can fix it. That's the challenge that we have here.

XXX: Let me say DOE is doing one thing which I think could potentially help fix it, which is you're funding the SPSC, SPSG and THE ICEPICK processes. So that's sort of a nontechnical barrier issue that I think you are involved in which is bringing our states together to start talking about those.

XXX: If I might add, natural gas at $, even if we believe those numbers, will stay $ if and only if we increase the efficient use of natural gas on the demand side to compensate or offset any transition to natural gas on the electricity supply side. There has to be a dynamic to ensure robustness or a more likely outcome of $ and then it has to still continue to decrease in the cost of energy services. It's not enough to stay at $.

XXX: As always, prices that balance between the supply and demand, you also have to invest in the supply infrastructure as well.

XXX: Exactly.

XXX: You want to go first?

XXX: I just want to comment on the interconnectivity. We heard this theme a lot about interconnection, interconnectivity. One of the things about renewable energy resources is they smooth out as you connect them. So if you don't have that transmission, then it's going to cost you more to get that flexibility. And it's just kind of the nature of the beast. So, I mean, I think we have to have a diversified portfolio where you have micro grids but we also have the interconnectivity, the transmission. Europe is doing both; they are building transmission, they're also building the micro grid.

So connecting the system together smooths it out. When you smooth it out, then you have this portfolio of ancillary services, of flexibility that you can supply, and that's how you kind of smooth out that intermittency of the whole.

XXX: Under Secretary Koonin, panel members, as a reminder, my name is XXX . I work for Salt River Project here in Phoenix. I manage our transmission and generation operation. Prior to that I spent 20 years in transmission planning, development, and research and development.

We, the utilities, have had a lot of innovation and creativity over many years. So the

question is why don't we perceive that that's happening?

And what I would think would be a good thing as a reminder is to note that we have a lot of history to deal with. When I say history, take a look at the size of the grid, transmission and distribution. Any time you want to affect that, everybody would like to see fundamental changes, not incremental changes. But the fact is there is existing infrastructure that has to be dealt with.

Take a look at our SRP distribution system. We have well over 120,000 miles of distribution system. So let's say somebody comes up with an idea that could improve our distribution system. How long do you think it takes to do anything? That's just doing the cost of construction, not even the human performance and not even the integration across multiple areas.

Take a look at even a subtransmission system. We did a study once going to the issue of facilities, overhead facilities. We said what would it take to underground all of the subtransmission in the Phoenix area? Take about 30 years to do it, just based upon all the issues you have to deal with, that being right-of-way, construction, outages, cost. But it's just the facilitation of all that.

When we get to the transmission side, it

becomes even more fundamentally challenging. Take a look at the equipment that's already in place that has to be dealt with. Then if you want anything different on the transmission side, I haven't heard anyone here yet talk about the issues of dealing with the Federal Energy Regulatory Commission or the North American Electric Reliability Corporation. Even if someone in this room today came in with something that was fundamentally sound, was excellent as far as technologically doable, had great pay back, think to yourself what would be the time frame to be able to move so that a utility could implement that. It doesn't go very easily.

And then as we talk here, there's a lot of individuals here, what they believe are the best approaches for DOE to take, in your paper that was distributed there were a lot of options to be considered. So the question is if you're looking at the transmission side, which ones are you trying to implement first? Which ones -- are they competing or are you prioritizing?

I do think DOE has a role in trying to figure out between industry, between the labs, between the universities as to how we take a look at putting this together as prioritizing, because we can't do everything at once. It's just not going to happen.

And so it's going to take a lot of

cooperation across these broad spectrums, not only just the different utility perspectives and their thinking but across all these areas as to where you start trying to make changes. You know, I think this group here fundamentally understands that the grid is the most complex system that's out there. I mean, we talk about the Internet; the electric system is more complicated and more complex. And borrowing a line I heard before is we don't want to tinker with it. Before you start making changes to the grid, it has to work, it has to work perfectly well, and it has to work reliably.

Unlike my smart phone here, I may not get reception here, that's just an inconvenience. If we don't have service that works all the time everywhere, we have a fundamental problem in being able to move forward. And we don't accept less than that.

Now, maybe, and I haven't heard this anywhere before, are the current standards in which we have, are they too strict? I think one of our panel members brought up before that as we look at a more robust system one way to get a more robust system is to take a look at do we need to have the reliability levels that we currently have. One way of having more robustness is to relax some of those. But, again, that doesn't come easily. That would take a lot of debate and ultimately

require approval from NERT and from FERC. DOE could assist in that. And then take a look at how we approach all of these things collectively.

And then as we take a look at how we -- we take a look at where the different research that's being done, sometimes we -- I think, XXX, you had brought it up. We silo things a little bit. And we need to ensure that the work that's done at the labs, the national labs, has overlap with what's being done by the universities, the universities have overlap with what's being done by industry. And that way we get that communication message because we don't want the labs doing research work that they don't understand how it might be applied. We don't want the universities taking the data from the lab and looking at applications of it without understanding what it's going to take to implement and operate. And again we need a certain nest at the utilities, back to what XXX said, understand what's been done in the supply chain of information to be able to want to implement that.

XXX: Good.

XXX: Thank you.

XXX: Yeah. Understanding the business and regulatory context with all of this, again a recurring theme that's come up.

We'll do one more and then I think we'll

break.

XXX: I just wanted to clarify a portion of my earlier comment. When I said military, I didn't mean invasion. I meant more some of the approaches they have, like sourcing and procurement, procurement especially. If we're able to create standards that can provide for some of what's foreseen and also in terms of future interoperability, it's possible that stimulating group procurement, which is one of the great strengths that the military is able to provide to existing organizations to innovate and entrepreneurial organizations, could potentially advance adoption in a lot of components of smart grids across the country. If we had to wait for AT&T to -- we might -- to do it, we might not even have mobile phones or micro grids or differences in reliability. But incredible jumps in performance today.

XXX: So there are many similarities and differences between defense and energy, but in general it helps to, A, have very clear mission goals, B, own the strategy, and, C, own the execution. And of course DOD does do that, or the government. And Energy completely different.

XXX: Potentially catalyze group adoption simultaneously while stimulating entrepreneurial

opportunities within standards and an interoperable parameter.

XXX: Good. Okay. As usual in these discussions, we've run over with enthusiasm. I think I'm going to turn it back over to XXX to tell us what happens next.

XXX: So let's take about a -minute break and we'll meet in the breakout room across the way at 10:25. I purposely let us run long because lunch won't actually be here until noon, so the lunch break -- there's no point in breaking at 11:30 when there's no food. So traditionally it's been hard to get people to stand up in the breakouts anyway.

So everybody should have a number on their badge. Folks who are -- otherwise, you can apportion yourselves as you like. But we tried to go through the list and make sure that the sets of folks who are assigned to different groups sort of covers the full spectrum of the kinds of folks who are here to be able to continue this sort of cross-cutting conversation. So we'll talk in the breakouts for a bit over an hour, and then lunch will be provided just out in the same place where the snacks and such are in between the two rooms, and then we'll go from there.

XXX: Thanks to the panel.

(Attendees will reconvene in breakout groups.)

XXX: We're going to spend the next hour or so going through a couple presentations by the folks who are leading the technology assessment team related to the grid within DOE. Those of you who know the DOE grid folks I'm sure already know XXX, XXX, and XXX, but I will let them introduce themselves as they come along, if necessary. But we're going to start with XXX Parks who will give us an overview and then he'll pass the baton.

XXX: Good afternoon. Part of our job here will be to keep you awake after the food, so we may have to make this a little more interactive than we anticipated.

Really appreciate the chance to be here and really appreciate the dialogue that we've had so far and hope we can continue that. What we wanted to do right now is just give kind of a snapshot of what really -- where DOE is on the space, what DOE is thinking about the space, and know that it's evolving in real-time and continues to -- this process and other processes will continue to impact that as we go along, including the technology reviews that we hold and the peer reviews we hold for the programs.

Also want to say this is a DOE perspective. It's not an Office of Electricity perspective, it's not (inaudible); it's looking at kind of our whole portfolio and thinking about how can we integrate in a way that we have not done as well in the past and get at solutions faster.

I want to take a second and say we kind of talked around this this morning, but electricity plays a vital role to our economy and our national security. I don't think that can be overstated, just how much this permeates our entire structure and our way of life. And I'm kind of reminded that in some countries around the world blackouts are measured in the number of deaths that occur. And I think that that really shows how much we rely on it in some ways, and it's crucial as it came out in the panel this morning that we think about if this is fragmented, if this is multi jurisdictional, how can we be smarter about the whole thing within the technology.

Complex systems, we talked about that a lot. I think another part of this that maybe doesn't jump out is it's a little bit of a system of systems. In one way we're talking about the T&D system here physically, another way the communication system has to tie to the in-loads, it has to tie to the generators, and it has to be the thing that communicates and controls that. And

that makes it a lot more complicated than just thinking about the wires that happen on the T&D system.

And jurisdictional issues at the bottom, you see how it's broken down from the variety of different ways.

So it's complicated space, and yet we need to work it. And indeed the federal role is somewhat justified by the complexity of that, because there are no other single actors that are going to do this, that are going to think holistically about this. And our partnerships with the states and regions are crucial in this space, and the partnership on the technology side. But it's so complicated that without some federal and federal-state and federal-private sector partnerships we're not going to move in my opinion very well.

The grid faces a lot of challenges. They're simultaneous challenges, and it's something that we have to think about, too. We can't just think about how do we get X amount of renewable energy on the transmission system. We have to think about what about electric vehicles, what about demand. What are we going to do about PV integration and how distribution circuits and how those interplay throughout the system with the rest of the removables that's in the portfolio, how much total variability are we going to put into the system when it

comes to removable generation sources.

So it is complex. There are a lot of opinions about what the future looks like, and yet we need to step back and say, okay, there may be eight different big scenarios we can put out. There's probably similar characteristics in six or seven of them that we can do with no redress, and we start to look at what are the fundamental things we can lay and foundations we can lay in there to move this forward.

Consequences of these changes. Capacity, you know, we have growth capacity, we have growth in use. How do we meet the projected demand for rights-of-way. Congestion is an issue now; it's costing the system a lot of money. Right now disruptions are a big issue right now in various ways. You'll hear a little bit more about that in the other presentations. Power quality and outages. It's complicated. And the national security (inaudible).

Tied to that in this space, because we're moving at the speed of light, technologies and Markets and policies are linked to this, and we can't really come up with technology solutions alone that are going to move this space. We have to think about how those other things are structured and how we could recommend that they be structured. So our interplay with the states and regions becomes very crucial in the dialogues that we have about

how we move forward. Our interplay with DOD becomes very crucial of how we move forward to find solutions.

Kind of how we look at things is we spent 120 years electrifying America. We did a very good job at that. The system, when people talk about the system, they talk about it's very efficient at this, it's very efficient at that. That's all true. It's all vital. And keeping those current attributes is very important.

But I think at the same time what we're trying to talk about is what does the next generation grid look like and is this a service grid. How do we get at these things and do we think of them indeed as services. Is getting access to low-power generation a service or is it a mandate that comes down? When it comes to individual consumers or when it comes to policies type goals, how do we get power quality, how do we get consumer participation. Flexibility in the system is crucial. How do you get dynamic protection, cyber security built into this, again, all at the same time. And are those things that people pay for in discrete increments? How could that even be structured?

There are a lot of questions that have come up. These are some of the ones that we threw out just to kind of frame a little bit about where we're going in the next three presentations. The system's been engineered

for 120 years. How do we really get at basic applied science to understand what's behind all this and make this truly happen? A lot of these questions you can read through; I don't need to read them all.

But if we're underutilizing capacity, how could we truly make that a competitive advantage. We have a system built out. That should be an advantage as a nation if we can figure out how to use it wisely. We don't have to rebuild the entire distribution circuit. What can we do smartly, what can we do to really make it competitive in the next generation and yet not have to reinvest all the capital required to build it out.

This uncertainty issue, you know, the number of things that are varying is increasing. It's causing the system to kind of operate in ways that we don't even know how it's going to react ultimately. We need to model that, we need to understand that, we need to move it forward. Very, very crucial.

A lot of talk about consumers in this entire process, consumers, how they engage, what they're looking for, what they're willing to pay for. I don't think anyone's adequately looked at if we do all these changes together what's the impact on the consumer and how does that change relative to business as usual. Because it's going to cost them something just to do business as usual

in the world if we move to (inaudible) as you look at things aren't going to be static, they will not be the same about carbon emissions in the future as you look at the EPA regulations coming down, you look at the worldwide impacts and pressure on carbon discussions. So a lot of things, how do we best move forward.

Under Secretary Koonin talked about the strategic plan. There are three specific short-term targets applied to modernizing the grid, understanding the grid with synchrophasors, putting those in. Those are moving on target. Deploying smart meters in American homes, you'll hear more about that again in another presentation. And storage costs, getting storage costs down. That's a start. And the question is what else do we need to do to move the space forward.

Thank you very much.

XXX: Well, hello there. I'm going to kick off the specific technology directions which we have been going. Obviously I'm going to do electrical energy storage, as I have done for the last ten years. But when I started in the field, electrical energy storage was a notion that most people weren't even aware of. You would ask utilities and they would say electrical what? And, you know, we had like one meeting a year, and that was my program review. We had very few actual technologies out

there which were producing live examples, and then only in the hundred kilowatt range. Although there were some big ones; EPRI did a really big one before the (inaudible).

But mainly we have seen this fantastic development over a considerable degree. We can credit ourselves at DOE in having helped bring that about.

There has not only been a lot of technology; there has also been a general awareness of the importance of energy storage in the overall scheme. We have, as of last year basically, some fairly influential people. Like Secretary Chu, Chairman Wellinghoff of FERC, and Terry Boston have come out with an appreciation that storage is going to be important if we want -- if we indeed want to have substantially more renewables on the grid. And of course it's not just renewables. There's a lot of other things that play into this game.

And storage is part of the energy strategic plan. In the process of modernizing the grid, we are thinking of reducing utility scale energy storage by about 30 percent. So this is a huge difference compared to the unknown technology of ten years ago, but we still have a long distance to go.

Now, what does energy storage do for us or what could it do for us? Well, it falls into quite a number of different categories, but more importantly many

of these could be done simultaneously. And if you want to develop the true benefit stream due to storage, we have to pay careful attention of how we bring many of these applications simultaneously on the system. For example, system stability. We can reduce peak load, we can improve base load capacity factor. We have heard about percent utilization. Not good. We can provide VAR support. We can defer transmission and distribution. A number of those, again, can be done simultaneously.

We can enable large-scale utility renewable integration, reducing variability. Ramp rate control, very important, something that has only recently come to the forefront. And we can generally help to increase dispatchability.

EV deployment is a new one, because EV is going to throw a real banner into the works at the distribution level. As you reach, again, a substantial amount of EV penetration, it's going to make life very difficult for utilities.

I pressed the wrong button. Who knows which button to press? There we go. Good.

Storage is already a reality. It is deployed to considerable degrees; most of it of course is pumped hydro, the big blue blob. It's about 99 percent. The other kinds of storage are tiny little dots,

planetoids. And one of our aims is to increase that amount because it's going to be difficult to get more pumped hydro in the United States. But in the United States, 2.5 percent of the national electricity flow already goes through storage. In Europe it's about 10 percent; in Japan it's about 15 percent. And the reason is obvious, because if you look at the lower left-hand corner, pumped hydro is the only one that is safely within the cost-effective range.

If we look at the overall thing, there are estimates that energy storage could grow from a $1.5 Billion business into a $35 Billion industry by 2020. So big plans.

There's a portfolio technologies that is available to us, and they are grouped here by size which, at the same time, is also the range of applications. On the right-hand side we have mature technologies, pumped hydro, compressed air energy storage. In the middle we have a whole host of technologies such as flow batteries, lead-carbon batteries, sulfur, flywheels. And then on the left-hand side -- these are the bridging ones, the ones that you would use for ramping, for example. On the left-hand side you have power quality and short-term applications, such as flywheels again and a good part of lithium ion.

Looking at a time scale in applications, for the short-time scale we have frequency regulation. In the middle we have ramping, which both refers to wind going down too rapidly, compensating for that, but it also refers to that period at the end -- beginning of the day when the wind generally dies down and the load comes up and there's a transition period which it is difficult to handle for utilities. And then there are larger scales where we are talking maybe a day, maybe four hours to reduce the peak.

In terms of where we are going, at the moment most of these technologies -- I'm now using a levelized cost. Okay? That means the life cycles are included. We are somewhere in between 10 and 100 cents per kilowatt hour per cycle, which is too high. We need to push this down to 10 cents per kilowatt hour per cycle and preferably down to about 4 cents per kilowatt hour per cycle.

Stationary storage targets, about here. The plug-in hybrid electric vehicle target is slightly higher, but they have additional stringent footprint requirements.

What does the industry expect? I did a little poll among industry folks. And these are their 10-year expectations. Pumped hydro is quite limited over 10 period because it takes almost 10 years to bring it

online. So there are unlikely to be more than three large pumped hydro plants to come online in the next ten years. Compressed air energy storage, more. I've got two going and there may be three or four in the works. Renewable integration, T&D support, frequency regulation, sizable Markets. Thermal storage, I don't deal with thermal storage, but it's an interesting thing and functionally just like other storage. And of course these numbers will be higher if, for example, 20 percent investment tax credit the way it has been proposed in Congress comes off.

A little bit of detail of some of the technology, centralization plants, pumped hydro, compressed air energy storage. There are things we can do for pumped hydro to make it more effective to, for example, allow broader applications for ancillary services. We can make the reaction time faster. We can have different, more modern techniques for finding new cites. So things to be done, but perhaps not spectacular.

Compressed air energy storage, the main thing is to get two done, because for 30 years nobody has done any. So if we can get two of them out, there is a queue of other plants that are most likely to be done in the United States.

There is also above-ground hydro, very interesting, adiabatic and hydrothermal. You have the

chance of having compressed air energy storage in let's say gas pipe, underground caverns with no extra fuel input. So that would be a truly green compressed air energy storage system. Interesting stuff.

One of my favorites, carbon-enhanced lead-acid batteries. You have got something that looks very much like a lead-acid battery, it's manufactured roughly the same way, but it gives you a tenfold or so increase in cycle life. You end up with something that behaves like lithium ion in cycle life but at the cost of lead-acid batteries. Trouble is we have some good ones out on the Market, mostly based on an Australian technology which we tested out in detail and which then was picked up by U.S. industry, but we have no idea why it works so well. You know, many things start that way.

But obviously the thing is you now recycle it -- I mean, you have gone into applications, you see the thing works, you recycle it and you do the research. So we are taking these things apart, testing different carbons. The topology of the carbons is vastly different. You know, what influences topology. And we want to learn why does this work so that we can first of all optimize the lead-carbon batteries and we can also learn how to build other batteries and apply the research.

Redox and advanced-flow batteries, we have a

whole agenda of how we are going to bring this down into a levelized cost of energy which can rival a gas turbine. There are many different couples that you can use, different chemistries. I have one that I'm -- that we are testing right now, 25 megawatts, and in the special set-up cost effective already. We are doing fancy things like working with new electrolytes that have the iron in them as a core. I like to call them metal spiders. You combine the metal with electric. The trick is to find one with high ionic connectivity and at the same time enough fluidity so it can go through the system.

Sodium-based batteries, this takes off on the sodium-sulfur battery which was invented in the U.S., worked out in painstaking detail in Japan. It is now available off the shelf, but a bit expensive. We can bring this down to a levelized cost similar to gas turbines. We want to make it planer instead of cylindrical. You know, we have all kinds of little things that we want to do with it to lower the temperature and increase the efficiency and above all lower the cost.

Lithium-ion battery is largely the realm of beagle, beagle batteries. But there are interesting things to be done such as, for example, build your electrodes in a self-assembled way. Instead of putting them together, have it on the nano scale but self

assembled. Two times reduction in cost, three times the cycle life, much improved safety.

So stationary lithium-ion batteries are always different from beagle battery. In fact, we have a consortium going at the moment, which is another dimension altogether, to get together with the beagle companies and with EPA to look at the possibility of recycling used second life of lithium-ion batteries, after they have reached about 80 percent capacity in the vehicle applications.

Flywheels. Very surprising. One wouldn't have thought so. But flywheels are actually extremely effective. We have a 20 megawatt in Stephentown, New York, which is going into service online this month. Okay? I mean, it's fantastic. We have another one of 20 megawatt waiting. We have a 20 megawatt battery technology one. So we have competing technologies, good for driving the price down. This works already. It's cost effective.

Where do we want to go? We want to develop flywheel, hubless flywheels. And both R&D and OE are working on funding that. There's also possibility of speeding them up fantastically. The energy is i-omega squared, Mb squared if you wish. Suppose you have flywheels that are superconductively levitated and spin at

a million revolutions per minute. Could be fantastic.

Emerging storage technologies. That's why I want to keep a portfolio of technology rather than pick winners. There is all kinds of fascinating ideas out there being hatched by universities and laboratories. Metal-air batteries, we don't really have them yet. But if we had metal-air batteries, highest energy storage density, but not yet regenerative.

An all-liquid metal battery, MIT idea. What if you have a huge tank of molten metal. Huge amounts of energy, basically a very simple system. Another one, an air-air battery, hydrogen, oxygen as your couple. Energy density is fantastic. If we have the right catalyst, if we learn how to work with nitrogen, could be an incredibly efficient battery.

Now, this has been on materials so far, but there is another angle which is to bring it to deployment. We want to technology push but we also want to do Market pull. And they have to go completely hand in hand; otherwise, things will stop. And through the ARRA stimulus funding, we have $185 million, but we received cost share of $585 million. Now, that is industry showing its readiness to invest in energy storage. We also have venture capitalists swarming around all our projects. And this is important because five years ago venture capital

didn't want to hear from nothing, okay, about storage.

We have three large battery systems, and I mean these are 10, 20 megawatt systems, two compressed air, one frequency regulation, a number of distributed projects, technology development aiming for less than $200 per kilowatt hour.

So we are doing Market pull, we are doing Market push, things are going along swimmingly. Instant success, just add money. At least a little bit. But, hey, I've put this subject on the map at $3 million a year, would you believe it. But working with the states, we had an actual -- we had actual budgets of 20 million.

Different technologies serve different grid requirements; modest improvements for established technologies like pumped hydro and CAES; significant potential for selected electrochemical technologies like lead carbon, sodium based, flow batteries, stationary lithium ion; flywheel shows potential with advanced technologies; and emerging concepts offer even greater benefit but much higher risk. Thank you.

XXX: Good afternoon, as we're loading this up. As the Under Secretary mentioned this morning, there are 17 technology teams, three of which were grid related. You've heard from XXX on energy storage. You will hear from XXX again on the

infrastructure piece.

The one I'd like to talk briefly about is measuring, modeling, and control. There is a team of individuals that have been looking at this with me. Several of them are in the audience, so I just want to acknowledge them, express my appreciation so far.

Measuring, modeling, and controls, part of the driver for this has been looking at the clean energy future and what the operational challenge is that is going to define the system. I would say it's not even about the future. There's some today that are also struggling with penetration of wind and other resources and how to balance them.

As we look at this, there's a lot of uncertainty. There's a lot of variability. The future generation resource mix is unknown. There's variability and uncertainty with wind and solar, so there's a push to look at new ways to be able to operate the power system, things like storage, natural gas, the role that demand response can play.

Load profiles are changing. As we start bringing in onsite renewable energy resources and demand response technologies, electric vehicles, plug-in electric vehicles, how is that going to play in terms of what the system must be able to accommodate? The ancillary

services, how these are valued, changing technology's end policy. Again, XXX mentioned early on about the policies and the technologies, but what will the effect be on future generation and transmission?

And then there's also the whole boundary themes issues. This came up a little bit this morning with the legacy systems. How do we start integrating technology not into just something that is a brand-new system, but we're dealing with something that needs to operate day in and day out reliably. And how do we start integrating technology into this in a way that can still transform the capabilities and the characteristics of the system sort of in our view drove the need to really think how to optimize the grid operations and resources in a dynamic way. This brings up several of the key attributes of what's often been referred to in the smart grid as sort of the multidirectional power and communication, sort of the adaptability of controls and protections, changing conditions. It's also in the long term thinking about how to integrate demand response and consumers into both planning and operations of the system.

Measuring, modeling, and controls group had three focus areas. The first was measurement and control, really about acquiring, sharing, and processing of data throughout the system. This is really about the real

time, taking the data in and putting that into action.

There was the communications and security, which is about having the backbone, sort of the enabling secure, resilient information backbone. And I'll touch on this in a little bit as well.

Modeling and analysis, facilitating system understanding, more I would say in the offline. Not really as much the real time you see in the control side, but how does that support grid operation, planning, Markets, policy decision making, technology adoption, which has come up quite a bit today.

The depth and breadth of data is growing, and what this is providing us is the ability to have demand-side flexibility to be able to meet some of the supply-side variability. Through the recovery act, substantial investment has occurred on the distribution side: 15 and a half million smart meters, sensors, switches, over 6500 distribution circuits or 800 networked phasors. All of this are providing a level of depth and breadth in data that we've never had before. And this really sets the foundation for a core sense of capability into ways that we could both understand the system and then how we can use that understanding to build new control approaches to operate and plan the system.

It's also the reality that this is only, in

a sense, a sort of small I don't want to say a scratch to the surface of where the potential could be, but it really only represents a small percentage of the household, and it's sort of a little bit of what the technology potential truly is.

But what we're still seeing is a significant impact that's occurring in this distribution automation technology, improved energy efficiency, improved reliability, operational efficiency improvements, lowering overall operations and maintenance. All of these are sort of driving the cost-benefits discussion as they are considered. There was a study that came out from PNNL that sort of focused on the value to the conservative voltage reduction, and I sort of bring out a couple points there as well in red. But you're seeing this investment turn into sort of value and return.

There's also the understanding I mentioned earlier on about the consumer and how they fit. And this really comes into that there's both a technology and a policy linkage, but there's also not one solution is going to be the only one for everybody. One of the projects is -- there's basically about ten studies that are going on that are looking at the benefits in various factors, and they're outlined here. One is Oklahoma Gas & Electric is actually looking at sort of the pricing strategy and

how it compares against technology to say, okay, how do the two of those play off of one another and what's -- what are you seeing from this and sort of really providing some insights there in terms of how sort of the regulatory system structures are appreciating or can complement some of that technology development.

Synchrophasors on the transmission side, team spent quite a bit of time looking at this. For those of you who are not familiar with it, synchrophasors provide GPS time-synchronized high-resolution data. So rather than a few samples every second or every few seconds you're getting 30 to 60 samples a second, and it's all time synchronized. So today what we're seeing is the phasors being used for forensic analysis, we're really seeing them being used for control strategies after an outage.

But where the team sees it moving is much more in terms of how does this become embedded into the control philosophy at the transmission and operational level. This includes sort of integrating renewable and variable resources, automated controls, demand response, increasing transmission system through-put, improving system modeling. The capability that comes out of this helps you understand grid stress, its robustness, instability issues, even reliability margins.

Under the recovery act, 804 PMUs are going in. This really sets the stage, basically puts in place sort of a nationwide coverage. There are going to be some additional opportunities for specific targeted phasor deployments, and the team didn't want to discount those. But as a whole what you see is a very broad, at least geographically, view of where the phasors are now being deployed, the data that they can yield in terms of the system understanding.

In terms of products, in terms of tools and platforms that can move you, enhance demand-side flexibility, we're seeing things moving from the monitoring to more the control side over a period of time. This sort of breaks it down in terms of different types of platforms that could potentially be investigated and be supported going forward.

On top of all this there is a realization that you need seamless communications, and it's not something that's just going to happen at individual levels. One of the things that strikes me about this graphic is basically some of the jurisdictional boundaries that have come up, sort of the ISO, the RTO, utilities, how all of this happens, the consumer. And at the end of the day, one of the questions that comes to be truly effective and to be integrated to what extent does that

seamless communication need to flow across the system, to what extent does data access become critical.

We did not focus on specific communication technologies. There were a lot of them. But what we wanted to focus on was a few -- basically three areas that we thought were critical, the trustworthy information sharing would be built upon. Those are standards. They're dealing with the privacy protection issues.

And then ultimately it's also cyber security. This graphic actually shows in the green basically the comparison of the intruder -- what the intruder knowledge needs to be to carry out an attack. And what you see is actually the intruder knowledge has been decreasing with time and the sophistication of the attack is going up, which means it could be -- people don't have to be just that really, really bright computer hack of the early 1990s that would break into a system. Given the Internet and other things, cyber security plays a very real concern.

It's also something that while we can -- another program says here's our goal, here is our metric we just achieved. In this area we felt that this is something that continues to evolve. And what we need to do as a country is be thinking about how can we, as partnerships and through the resources we have, support

one another in continuing to stay being in the forefront and understanding what the threat and what the potential opportunities would be.

Modeling, analysis, this is the third element that I mentioned earlier. So measurement and controls, (inaudible) communication, (inaudible) analysis, this really helps us be students of the system. We thought about accelerating performance. How can you increase the performance of the tools you already have. How can you increase the predictive capability of these tools. And it's also how do we start integrating across modeling platforms, really understanding the interactions and the interdependencies that can help guide technology adoption, can help guide what policies could be effective.

Performance and predictive capability, this is not just about taking the problem that we have today and throwing it on a super computer. What this is is about thinking how to improve the way we approach the problem, how to shift from using offline analysis and conservative margins to really saying we now have this ability to leverage this real-time data and some of the dynamics that are part of the system, that are critical to sort of understanding the variability and the flexibility of the system, and build this into an understanding that doesn't allow us just to react but to predict where the

system is going so that we can sort of mitigate the effects.

Right now we're also looking at a lot of it's based upon the operator having to be able to react under fast decision-making processes when an event occurs on incomplete data. How can we start helping with whether training or other ways to be able to support and improve this process.

Modeling platforms. There are a lot of models that are out there, a lot of them have come up today. You can find just about every one, people -- I've heard GridLAB-D, I've heard GE ones, I've heard a whole bunch since we were here today. And the question is each of these in and of themselves has a lot of merit for answering the questions that in itself is being -- that they have been designed to answer.

Now the question is how -- as we start looking at these system level problems, how can we start feeding data from different models into other models to be able to enrich both the accuracy as well as the capability of this as a whole. This really helps whether it's feeding in more distribution network modeling and to help so that you can understand demand response into transmission systems, this can help with understanding the dynamics and how that can impact other types of -- I mean,

this -- or even just dealing with aggregating the data as a whole, just getting a better understanding of the system.

Finally, there are a few areas that the team talked about in terms of emerging areas in terms of modeling and potential capabilities that could be pursued. One is just dealing with this uncertainty issue, whether it's wind generation, load, contingency, just the whole spatial temporal dimension, and the graphic there on the bottom right really talks about -- I mean, you have transmission citing and construction which is out 10, 15 years. At the same time, we need to be thinking about Markets, we need to be thinking about protection, we need to be thinking about real-time controls, we need to be thinking a month before that about relay sets. How do we start thinking of this in a different way?

Ramping, economic mismatch, dynamic effects. Infrastructure interdependency, that's something that comes up a lot. And then it's also this whole issue of pricing. How do you start to cooptimize all of these different factors and also at the same time capture consumer behavior.

I thank you for your time.

XXX: I'm going to switch here a little bit, because we talked about storage and we have

some critical mass in the program. XXX talked about the things we're doing that start to get to modeling and control. I'm going to talk a little bit about hardware and about (inaudible) electronics.

And I think what's a little different in this space from a DOE perspective is hardware investments are pretty expensive. And we've done -- we've had some home-runs in this area, but in general they've been one and two of a kind kind of things, not dedicated, long-term programs that would have (inaudible). So I think what you're going to see is a picture that's kind of mixed. When you look at what's gone on in the past couple decades and kind of where the future is going, and it gets back again to what is DOE's role in this space.

We talked about how this is an evolving system -- I think we all know that -- and to enable this, the infrastructure must evolve to meet these challenges.

Bulk congestion and reliability issues, the solutions that come into this can come from the lines, they can come from the substations and nodes in the system. And how do we go about that? Even though there are a large number of those, it's going to be crucial how we think this through, how do we relate back to some of the things that XXX is talking about or XXX was talking about.

Advance substations can enable us. We can start to look at power that could be actually routed. And we know we're sending power where we want. And I'll talk a little bit more about that. And the substation components can become important, looking at the individual not only the components themselves, the transformers, converters, FACTS and controllers, breakers, and I'll touch on these, but also the basic materials behind them and the science behind them and do we need to fundamentally rethink how these things are acting in the world that we're trying to evolve to today.

If you look at what DOE has done, the circles around are places where we have touched in the space and made some contributions, but other places that are either shorter payoffs or longer term payoffs in the sense of more indirect. And an example of that is there's been a great deal of basic science work on materials and dielectrics and insulators not necessarily targeted to the grid. So it's a question of how can we mine that data and utilize that or even in the future get it more coordinated toward where the needs are of the system.

Reconductoring is the big issue. If we can utilize the spaces that exist now, that we already have access to, then in the next ten years that's a really fruitful area to look at because we don't have to think

about new rights of way. So how do we do that? Historically we've built bigger and bigger lines. Reconductoring with advanced cables and conductors, higher power densities, more power loads and lower voltages, there's different ways to make the system work is kind of where the trend is going.

People talked about New York some this morning. Building new transmission lines in New York City is really, really a problem. And they need to break through in super conductors or something equivalent to that to really get the density of power to move in the system to make that happen.

So we can think about this probably as a systems thrust of where DOE could have a real impact in the system and how we can address some of the capacity issues.

We have done some work in conductors and cables. We have four demonstrations of high temperature super conductoring systems out there now. (Inaudible) system is 138 kVs, the highest power SCS system in the world. Those are demonstrations that will stop. They're not really at this point key to push into the Market further and to make that happen. I think that's a big question as to where is this technology going and at this stage of evolution.

We also work with M on their metal matrix core conductor, and just in February they celebrated at their plant moving a thousandth mile through the system, through their plant. And that's key. It's an expensive technology, but in certain areas it's the only solution, can cross rivers, cross environmental sensitive areas, can carry a lot more load than conventional systems can.

And we've had work going on at Georgia Tech and other places looking at are there other special modules we can put online to understand what's happening better and to utilize, again, rights-of-way that are access to those lines.

Then there are targets that we can set, going after new overhead and underground cables.

We talked about routable power. Looking at work going on in this case, if you could actually move power the way you actually wanted to, it's percent of business as usual in terms of the power needed to satisfy the problem that you're after. It's a very high impact area, very hard problem. It's going to take a real concerted effort to make this happen. And there's one project right now in this Department.

Power electronics, huge area. A lot of work worldwide happening in power electronics. Less so targeted to high power electronics. So it's, again,

looking at what differentiates the needs of the grid for these devices and do we have the right materials and the right systems that we're going after.

FACTS devices, there are one or two in the world operating. Costs are too high. How do we drive the cost down in them? We know they work, we know they'll help the system. How do we get at that? Is that a target area?

Power converters. If we're going to push more D.C., if we're going to talk about multijunction D.C. links, we don't have the systems to do that now. It could be a targeted area. And we could look at that, and it leads back to if you can do critical connections on shorter D.C. links you can start to move renewables in different places. It's a relatively simple solution set compared to building an entire network that has to move the system.

Power electronic devices, again very important. Advances in semiconductor materials are crucial, and we have a few targeted, very good project activities going on in the space, both R&D and ourselves. But the potential -- if you look at the bottom, the potential for operating temperature increases, the breakdown of voltage potential, they're huge in the material space. How can we get -- move into the applied

space and move this into devices that could impact all across the grid system.

Advanced transformers, this is a critical piece. Not a lot of work has gone into this space. We currently have one project on transformers. I'm aware of three projects in the last ten years that we've worked on advanced transformers. We showed potential to increase. Hasn't moved into the Market space. So it's not -- how do we be more successful with targeted things, what are the priorities to go after, what are the big impacts to be found. And in this area DOE has not been strong.

Protection devices, two-way flow. We talked a lot about that in different various ways today. If we can get this, if we can build systems, it's going to change the system. Do we understand the changes to that system? For example, are we going to get bigger fault currents? Yes, we probably are. How do we deal with them? How do we have equipment, you know, that will arrest that development? How do we go at different kinds of switches and breakers to make that happen, again back to the D.C. And how can we project the equipment that we have in and the future equipment that we want to put in in areas for targeting. So we talked about that.

The last thing I wanted to mention is we do have in the 2012 request a smart grid technology and

systems hub that we want to go after, and this really targets around the substation, to rethink the functional characteristics of those components and the material means for a modern grid. Really come with a concerted effort can we build a different kind of substation and the components around it at a junction where a lot of this communication has got to flow from both sides and it needs to figure out how to handle this. And we might just be able to make a leap-frog activity here.

And I'll stop there. And that summarizes the DOE presentation. Thank you very much.

XXX: The grid guys are good. Previous workshops ran over.

We have a few minutes. If there are questions for any of these guys, now would be a reasonable time for that. We are scheduled -- we could go now or in five minutes or so to break out to talk about more technical issues. There were three presentations, but with this size group it's too big to break into thirds, so we designed these four general topics for breakouts. And I'll leave these up if anybody has any questions for these guys on details of their presentation, and then I'll come back up in a moment and talk a little bit more about the goals for the afternoon breakouts. But were there questions?

XXX: I had a question for XXX. In the presentation and then in the document you talk about robustness of the system. You talked about utilization. And what I'm trying to ascertain is are you seeing those as diametrically opposite issues, or are you proposing that those are in somehow link and parallel and you can get both?

XXX: Well, we hope we can get both. The flexibility of the system is going to be so key because there are just so many variables we don't know, for example the future generation piece. And so ideally we go after both.

XXX: I agree.

XXX: So can we find ways to do that. Things that seem to be contradictory, can we change the game, can we change how we come at this in a way and make that happen.

XXX: So that's more of a question as to how can that happen, or are you looking at something else that you think can actually get us there at this point?

XXX: In terms of the robustness issue, I mean, I would argue that things that we're investing in right now to get a better understanding of what's happening before storage is an issue could provide

a level of robustness that would improve the overall (inaudible) the same utilization. So I would say, yes, we are making some investment in that area. I would say there could be considerably (inaudible).

There's other technology issues that could be explored that we have not explored to date. You could maximize the --

XXX: Okay. I just need to get a handle on where you were headed with that particular set of framing questions. So thank you.

XXX: Other questions?

XXX: So as we start to develop new hardware technologies, what is the likelihood that U.S. industry will capture these rather than seeing them go abroad? I understand, for example, that the substation transformers we don't do in the U.S. anymore.

XXX: Or breakers.

XXX: Whatever. Right. Yes.

XXX: So that to me should be an incentive for the U.S. government to say let's change the game. Let's figure out if we can figure out a different way into this space and then we can control that space. And I think that's worth thinking about. What are the characteristics that would change and these guys would then produce what they produce. But if we're really

coming at it a different way -- and that's the challenge, can we be good enough to do that.

XXX: Other questions?

So the way the afternoon breakouts work, you're free to pick which -- there's no way I was going to be able to know, looking through the invite list, which would be a group any of you all wanted to join. So please assign yourselves. If one group is really big and another group is really small, if you have a secondary interest in the other group, for balance that might be appreciated.

A little bit of sense of what kind of areas we're trying to cover in the afternoon breakouts, we're really trying to get a sense from you about where you see these fields going, where -- what are the milestones, what are the important pathways that need someone's attention and, secondary to that, is that DOE's attention, is that somebody else's attention. Also, more fundamentally were there things that you thought should have been in these presentations that weren't?

These are basically the -- these presentations are essentially summaries of the technology assessments that are going to go into our thinking as we pull together that logic flow to build the QTR. If things were missing or things we have wrong, we need to know about that. And so this is a chance to get essentially

peer review of where we think we stand on that.

And, yeah, if there are particular constraints on these pathways or particular pathways you think are mentally fruitful, would solve problems for you that are generalized national type problems, highlight those for us. And generally just try -- we're trying to get a sense of this whole space, what we've got right, what we've missed, and a sense of priorities among all the different kinds of technologies that you just heard about.

So we're scheduled to break out for about an hour and then take a break. So I think we'll do the same -- the same physical tables will carry the same numbers as they did this morning, the pieces of paper should be on the table, and pick your number and go to it.

(Attendees will reconvene in breakout groups.)

XXX: We're going to get started back up again. I will stall for ten seconds while I wait for anybody that's out in the lobby to come in and join us.

What we will do for the next 15, 20 minutes or so is to have folks from the QTR team who are participating in the various technical breakouts give just really short report-backs so everybody can benefit from conversations they didn't get to participate in. After we

do these technology-specific report-backs, Mike Holland is going to take over. And the team huddled over lunch and sort of compared notes about the morning breakouts to pull out common themes or particular interesting ideas. So he'll do a quick run-through of those and we'll go back into more open conversation.

So I had the pleasure of participating in the system awareness and control technical breakout, which as somebody who as a business who did control theory for quantum mechanic systems was interesting to listen to the same thing for something pretty close to the opposite end of the scale spectrum. So we had a conversation that spanned over the course of the full range between (inaudible), communications, necessary processing. So -- while talking about decision support in particular, including how -- what the role of humans are in controlling the grid, and then some about what the actual actuators are for demand and what those actual -- the actual lever that you hold to control the grid actually is.

So most fascinating part, or a particularly fascinating part of the conversation for me was the question of the human interaction, where we are on human interaction in the grid. What we used to have -- was news to me; I'm not the energy expert -- there used to be

humans in substations. In my lifetime I've never seen a human in a substation. So we managed to abstract the level of control enough to not have -- not need a human at that spot.

So we're on some trajectory potentially towards not needing humans elsewhere in the immediate control of the grid as well, and the question is how are we actually going to get there, will we actually get to a place where we have what's described as a fly-by-wire grid, where there's no actual human with the manual control directly onto the actual actuaries in the system.

One thing that was notable is that people, both policies and actual training and such, are slower to change than software or perhaps even some hardware, and so that will have an impact on the time scales for potentially implementing sensors and controls and such.

Talked a lot about what the actuation for controlling the grid is and particularly in terms of controlling demand, that thinking of controlling demand as essentially interrupting individual loads rather than uncontrollable load shedding, perhaps blackout type circumstances. And we talked about the need to actually understand the system better and where we actually are in the dynamics of a complicated system, understanding how close to the edge actually we are in terms of stability

and how could we operate the grid more effectively to actually operate -- utilize its resources more effectively, which would mean generally operating closer to the edge, risking stability perhaps -- but, you know, you want to maintain stability, reliability, robustness, but get more out of the grid that we've got.

And interesting to learn that the time scale generally thought among the individuals at the table for actually implementing these kinds of stuff, new technologies, is really in comparably short term, five to ten years, which compared with the time scales for developing say in the nuclear plant is actually pretty packed.

So with that, are there folks from my table who -- did I miss something? Is there something important that I missed that you want to add?

I will turn it over to whoever was at table .

XXX: So I'm going to try to give an overview of some of the major themes that resonated with the modeling group. The first really dealt with ability and need for access data itself, investments and models and simulations pretty much mean at the end of the day we need to have realistic and accurate data to be able to validate and verify what specifically we were trying to

do.

Related to that was sort of the institutional divides that were out there. We don't have publicly available real test cases. There were issues discussed about operators not having access to planner's data, sharing between ISOs, RTOs, between utilities, even though some of their actions were both complementary and sort of there's some interdependencies there as well.

In addition to the data, there was a recognition of the need for concurrent development of applications, but at the same time there's no standardization of data, there's no standardization of models. There's no national steward right now for tools and modeling capabilities, and that extends right from the planning through the operation on out. There was some debate about what the role in the government should be for that purpose. Development of new modeling capabilities, using some of the phasor data to be able to validate and verify some of the modeling tools.

Suggestions were raised about simulations, sort of look-aheads to help the utility with understanding if they take a certain action what might that mean in terms of future predictions of where the grid would be in terms of especially dynamics. Not just steady state but sort of the dynamic aspects across the system.

A lot of focus in the discussion as a whole on themes issues, whether it was across models, whether it was across jurisdictional boundaries, whether it was across data sources.

Then finally I think the -- well, actually, two last points. One was dealing back to the theme of flexibility. One of the -- there was one comment talking about do you need to focus models on achieving an optimal solution for a particular case or do you need to be thinking about a model platform that ensures the breadth of coverage over all likely options that you may see. So it may not get that targeted optimal result, but, yeah, it gives you the flexibility to accommodate the breadth of what might occur.

Then the last one dealt with the timing of this. A lot of discussion about what are the potential implications in terms of what it took to develop modeling platforms. There was a lot of discussion about, oh, well, maybe we could do this if there was concerted effort and there was agreement and data. Laundry list of assumptions. But maybe this could even be done in the two to three years. So it's not a 20-year-out type of research activity, but it's really something that could have significant impact in the shorter term.

I guess on that, I know there are a lot of

people in the room that were involved in this group. If there's anything I left off you want to add. Once, twice. Nope.

XXX: So I was in group 3, which was storage, ancillary services. And was a lively discussion, a lot of really interesting insights.

There were kind of two main themes that I heard kind of came up again and again, and they were related to the kinds of studies and forecasting that DOE could sort of help with and the need for databases of information.

So on the study side, seemed like there -- the kinds of studies that would be helpful would be cost effectiveness of different kinds of storage for different sorts of services; the impact of geographic diversity on storage needs from area to area; and also just the need for kind of forecasting in general to know -- to optimize kind of storage that you would put in place.

On the databases side, I heard that a general database of all the different storage projects, both that have been funded by DOE, that have been put in place internationally just to kind of get an idea of where they are and kind of a set of data about all of these, who owns them, where they're installed, what kinds of storage there are, and then try to collect some lessons learned

from all of those and also if we could get access to the raw data so that people could do studies and analysis.

And then there was another idea that just the one collection of all the different regulations that are in place with respect to installing storage was a big need.

There was some discussion about the impacts of electric vehicles on storage in the grid. And the theme I heard is that using electric vehicles as a sort of distributing storage mechanism was probably unlikely.

In terms of community energy storage, there was -- I heard from many people that community storage would be important in the future and is an integral part of kind of distributed energy, was a nice complement to bulk storage.

There was a lot of discussion of different business models and how you fund storage, so how you spread the different rate to different ratepayers, the different kind of revenue streams which would be necessary, how you're going to need different -- to provide different ancillary services, and you need open (inaudible). In terms of kind of buying and selling, (inaudible) doesn't really make sense, but that storage should be like a pay-per-service charge.

I heard that DOE's role in this area should

really be on incremental advances and deployment, not -- because the challenges that require the storage are so immediate that DOE should really focus on the near term, and that pilot projects are really important to get the lessons learned. And that DOE should support these pilot projects to multiple different funding mechanisms and really follow through so that the supply chain can be developed.

And that was my rundown. If anybody from my group has anything to add, feel free.

XXX: One thing we also said was that storage benefits from having Markets, so be able to sell them to the regulation Markets, for example, (inaudible) is important, also.

XXX: The other thing perhaps it wasn't just support for demonstrations and analysis; the support was also there I believe for more basic research as you cycle back and need more technology development.

XXX: Okay. So I had the end-use participation breakout session. So one of the issues that we discussed was this human technology interface. One of the questions was whether it was too complicated to really deal with in this way, sort of the feeling of some players in the utilities to maybe pull back, thinking it's too complicated and we're just the infrastructure providers

and to leave it to somebody else to deal with.

Then the question was is DOE the right party to do that. We're seen and we often see ourselves as just the technology developers. So there was some discussion of whether we understand the customers well enough and whether -- and who should -- and who should help us with that.

The question when it came to the issue of integrating electric vehicles into the system, there was a viewpoint or view that the grid and the utilities in the system have a different viewpoint of what's acceptable and not acceptable, and the consumer might not appreciate that tension, is an issue that we have to think about.

Vendor. There was an impression from some of the parties, people there, that the vendors may be nervous about mandates or about standards, and part of the worry is that the rate of change of standards is much more slow relative to the rate of change of technical innovation. And another view on vehicles and, you know, the utilities are not seen as having any deeper understanding of consumers, so that makes the integration (inaudible) a challenge.

When we were discussing the security issue, there was some discussion of who in the government should own this or what was DOE's role in that, should Department

of Homeland Security do that or something like that. But the point was made that given that you need to build cyber security into the technology from the get-go that DOE needs to be engaged on this issue. And that when it came to security, cyber security was only one of the issues that we should be thinking about. There was the physical security of the systems and the fact that when you start having distributed entry points to the grid with all sorts of interfaces that when you are rapidly increasing the number of things that you have -- points of entry into the system, but also privacy issues are also something that require attention, the kinds of information people ask back and forth between consumers and utilities with other parties is an issue.

Another couple of issues from the technology breakout that came up, when sort of -- the Department may not be particularly good at communicating to all the relevant parties in the -- that are engaged in these discussions, and so with consumer advocate organizations, they hear regularly from, say, FERC, but not necessarily hearing regularly from some Department. That's something that we could improve. The Department ought to also in this arena go back and look at the -- some of the coalitions that were put in place to respond to the built-in hub, that a lot of the parties that did not win

put together very interesting groups that we could see if there's something that we can go back and learn from and maybe build upon.

And then finally when it comes to this end-use participation issue, there was -- the question was who -- or how strong a role does DOE have in this given that there are public utility commissions, there are consumer advocates, there are other parties who are closer to the consumer and much more likely to have a better pulse or better feel for what their interests are, and you also get into issues of federal government entry into other parties, their roles and stakes and so forth.

Then I will give a couple of minutes' summary of the morning's breakout sessions, and this is sort of the integrated whole from all four of those groups.

One of the -- I think the clear thing that we've heard from multiple parties on multiple topics in this arena is that DOE brings a lot to the table as a convener and an educator of various stakeholders, that we have the ability to bring groups together. Regulators, utilities, vendors set a vision. We can serve as a somewhat independent third party on identifying what has worked and trying to get the group to move forward on those.

One of the challenges is that that is difficult for the Department to explain, document, and measure the value of that role as a convener. And so the countervailing force of it being easy to document, explain and measure technology development probably puts this in a bit of tension. That's something that we have to work on doing a better job of.

The point was made that regulators and consumer advocates need information on the success and value of various -- sorry, the type of technologies and technology demonstrations to achieve confidence in the value of cost recovery and that that -- and reaching out to those parties can help speed the penetration of and diffusion of technologies.

One of the points was made that EPRI was very good at this role as a convener in the '60s and '70s. We may want to go back and look and see how they did it and see if there's something we can learn from that.

In terms of the goals of the Department in the grid, we can use this aggregator role and convener role to create targets for utility companies and stakeholders, sort of maybe we can do a better job of using our bully pulpit; that the metrics for the grid need to be based on future Market not current Market conditions so that items like transparency usage, robustness, or

someone identified undelivered energy, that's something one would want to minimize.

Other goals. In terms of taking our high-level goals that we set, that we might then try to couple those to state level goals or aggregate up state level goals and then use that to set intermediate steps, intermediate goals to achieve the long-term national goal. So, for example, percent clean electricity by 2035.

Comments on the composition of our portfolio, we are possibly too widget oriented and that there's a significant role in fundamental engineering, understanding the grid and its performance. The comment was that DOE should invest where industry will not, and so there are enough people who are focused on developing the technologies themselves and that we have a stronger role in pulling everything together for a system implementation.

There was some discussion in various groups of sort of what a proper balance in our portfolio would be in terms of short-term focus, medium-term, long-term. And of course I put some numbers up there. All sorts -- all over the map. But some people, basically it was like, you know, focus percent of your effort on the short-term stuff and really who cares what the distribution is on the other part.

A time horizon for impact of our programs, given that physical scale, the capital exposure, the durability of those assets means that infrastructure, deployment replacement is planned on these 10- to 15-year time frames and therefore incremental improvements are far more important than say something, you know, radical or (inaudible).

In terms of system models, we don't have models that can give utility commissions -- or that we can give to the utility commissions to show them how -- if their systems would improve, and therefore utilities tend to stick with proven technologies because it's harder to get the approval for that.

And then we had some of the identification of this sort of chicken-and-egg problem for demonstrations, where you need to have some standards in place before the technology is allowed into a demonstration at scale, but that you have to figure out how to get the standards in place to enable that. So figuring out how to do that is a big challenge.

I will turn it over to XXX to wrap up the discussion.

XXX: Good. All right. So we are aiming to finish. My guess is that we will finish earlier than the scheduled 5:00.

The floor is open to react. We're most interested in what the DOE's role should be here. We are, as I've seen it, you know, a small amount of money in a domain that is vulcanized and is connected perhaps loosely by EPRI for some research. I was amazed to discover the ISOs don't talk to one another very much, you can't get data to validate models across, et cetera, et cetera. So it seems it's a somewhat chaotic and confusing situation. And what is the DOE's role?

XXX: Just one observation. Recently DOE worked with NERT on putting together a report on high impact, low frequency events, so kind of the things beyond the normal responsibility to industry, so to speak. And I didn't hear a lot of that today, but I personally believe that's very important for us, you know, for national security and homeland security perspective, you know, thinking about physical security, cyber security, large weather events, solar storms, things that could affect our infrastructure that's sort of beyond the contingency planning horizon for what industry would be expected to deal with. And kind of gets into the resiliency of our infrastructure and things like that.

XXX: DHS's responsibilities, too, at some level, right? FEMA.

XXX: Well, I would hope that

DOE would take the lead on that, but that does seem like a federal role for sure.

XXX: So I was just going to echo Jeff's comments, because when you talk to the utilities, they're focused on serving native load as a cost effective -- most cost effective manner, and that's what they're driven to do.

And so it's the opportunities base that we didn't have enough discussion and I didn't hear that enough. It would be interesting to get other people's comments in the room on that space.

XXX: All right.

XXX: I'd like to make a comment about I don't think it's quite true that the ISOs don't talk to each other. We do. And we also exchange the models with each other.

XXX: Oh, really?

XXX: We do. The problem I think today is the research community cannot give response. We have the critical infrastructure rules that prevent us from giving it to any academic or any other research entity. I think that slows down research, because I really cannot check the models or the theories or whatever they do. We internally have the information policy that says if I want to give it to somebody, a member of

(inaudible), for example, they have to have permission from every stakeholder (inaudible). That means all --

XXX: So does that preclude the national labs, for example, from hiring --

XXX: The only entity I can give the model if they ask is FERC. Everybody else has to have a non -- not -- even nondisclosure agreement is not enough because you need to have a contract. So I give it to our vendor of the software because we have -- not only do we have nondisclosure agreement but we have a contract. Everything else is impossible to do.

So I know that people that do R&D are suffering. And if anything could be done, it should be done. Because it's so easy to overdo security, and we do that quite a bit.

XXX: Getting back to XXX and XXX's comment. We actually did have a little bit of discussion, again on our first breakout session, and you made a point about DHS. Now, they'll -- my experience with them is they'll say that they don't have a responsibility for design of the grid, for example. They'll assess its security and work with the owners and operators to secure the system, but they're not going to set a vision of how it should look in 20, 30 years from now.

So what I've observed from the utilities is they basically -- they're bound by whatever regulatory requirements they have to abide by, the reliability requirements set forth by DOE and then by economics. So a lot of times those are not really looking out for the larger systems development good of the grid, of the energy system for national security. First of all, they have to take care of themselves and they're in survival. So that's where I see DOE really has to look at the larger system, and I think the systems perspective is what's been lacking in the design and evolution of the grid.

XXX: Even if we had an optimal design or a better design than what we have, there's still a question of moving the system toward that goal or in that direction, and that requires cross coordination with the regulators. Technology is only one leverage area and maybe not the most important one. I'll come back again that this is more a regulatory organizational kind of problem than it is a technology problem.

Nevertheless, the modeling can certainly help and maybe there are discrete technologies that we should be looking at, some of which we discussed earlier this afternoon.

Anybody else?

XXX: I'll try to talk loud

enough. But I want to just make a comment about international cooperation. It's something that XXX and his team put a priority on, and I think getting value from that international cooperation in terms of lessons learned. And I wonder if that should just go in as an element of projects to see what's going on internationally. And, you know, not fund internationally necessarily, but the Europeans have a technology roadmap that's actually a very good document and a deployment roadmap for that technology, and I think there's a lot of opportunity to compare notes and just get into projects, making sure we're taking advantage of what's going on around the world as well as part of the whole research platform.

XXX: So I'm interested that you mention Europe but didn't say China. My sense is China is deploying technologies that are maybe two generations ahead of what we're doing here in the U.S. Is that a fair --

XXX: I think coordination with China is important as well.

XXX: Well, in the storage field, I think we need (inaudible), and China would very much like to join with us.

XXX: I see.

XXX: But it's not only that China is one of the biggest battery manufacturers now; they're also one of the biggest Markets. So it's distinctly in our interest to interact and know what they are doing and perhaps lead to a collaboration which would be to our advantage.

XXX: That's assuming again one can have access to the Market.

XXX: Especially in areas where we are developing open source tools anyway and things like that, just let's go see if they'll use them and develop them in parallel.

XXX: I'll just put in a plug for the North American SynchroPhasor Initiative. And we have (inaudible) work groups every year, and every so often we have one that's dedicated to let's look at the process outside our areas, South America, Europe, China and all over.

XXX: The synchrophasor deployments elsewhere, from other grids?

XXX: Yeah. Exactly. Because there's a lot going on worldwide. So I'll just put in a little plug that we have one of those programs.

XXX: Other discussion?

XXX: Coming back to the

comments you were making about the -- in what direction the system should go, you said it's kind of a regulatory issue maybe more than the technology issue. But you can say, well, nobody is really looking at what a good system would be from a bigger perspective. So that may be a role for the DOE.

XXX: Right. Again, with the various dimensions and metrics of goodness.

XXX: Yes. And taking the other stakeholders together.

XXX: That's good. I mean, is there -- you know, you can say clean slate, right? Let's design a grid from scratch. And of course you can't get there from here very easily or very quickly, but nevertheless it gives you kind of a vision. Has anybody done a study that says this would be the optimal grid?

XXX: Pieces and parts.

XXX: Pieces have been done and parts.

XXX: I wouldn't claim that that -- the people have tried to -- there is an effort that (inaudible).

XXX: There's no one alternative; there are several.

XXX: There's no one alternative;

there could be several alternatives.

XXX: And all of them could survive. Depends which one --

XXX: Depends what direction everyone wants to go.

XXX: I do think it's good to differentiate between -- what historically has been done is bottom-up planning for transition generation. And when you have clean energy technology such as wind, energy source, top down, you learn something from doing both methodologies. You learn something new. So you have to have that diversity in analysis, diversity in modeling, diversity in understanding the grid.

XXX: Again, come back to the optimal. And it's sort of a natural question to ask is how far off from the optimal are we? How much more efficiently could we use assets? How much more robust could you be? How much more emissions -- well, that's on the generation side, talk about emissions.

Those are natural questions to ask. Maybe we're within percent of optimal anyway. We're not. Okay.

XXX: I'm not sure that that question really has sense, because it's a bit of a chicken-and-egg question because the generation will tend

to locate where you have transmission and then you sometimes build the transmission to meet the generation. So you have to look at where you are.

XXX: So it's not -- it's an evolutionary kind of thing. We can't move the generation easily.

XXX: I will push back a bit on that. I'm not sure I entirely agree, because we know that the grid has been holding at about 32 percent efficiency since the '60s, unchanged for the most part even today, all these years later. And if we're talking about modernization, just a better way of getting 32 percent efficiency, that's not modernization in the best sense of the word.

I think studies suggest that with real integration of real-time information and pulling in diverse players, consumers and producers, we could be thinking in excess of 50 percent efficiency as a starting point. It could go up or down depending on real-time estimates and the like. But 32 percent efficiency since '62 ain't anywhere close to optimal.

XXX: So should I take, you know, some issue with the fact that you say 32 percent, which is the total energy efficiency from the chemical energy or nuclear or whatever it is all the way through to end use?

I would've said the grid is like 92 percent efficient. You take the electricity from the generator and move it --

XXX: But we're talking the system. It's enabling. We want the grid to enable larger opportunities for the economy.

XXX: More efficient generation.

XXX: Right.

XXX: When you say optimal, we have to make -- meet some objective.

XXX: We have to decide.

XXX: Optimal from (inaudible).

XXX: So somebody was talking about robustness against asset utilization, right? Do such curves even exist? I mean, you can sketch a thing qualitatively. But has anybody really tried to calculate if their asset utilization was up at 80 percent how much would you sacrifice in reliability?

XXX: Yes.

XXX: Such curves exist?

XXX: Yes, that information does exist.

XXX: On the same topic of how do we improve the efficiency of the machine, the big grid, over time, as one artifact of our organized Markets is that there's not much collaboration that goes on with the

grid operator. So, for example, if you go through a process of citing a 20 megawatt energy storage facility you really can't ask the grid operator where the best place to put it would be from the standpoint of the grid.

What they do is they kind of hide behind this notion of competitiveness and you can't get any intelligence back that says this is how we could kind of optimally piece this thing together.

Similarly, same thing with locating generation and I would assume transmission. So that is a real impediment, just like this impediment of not being able to share information because of the reactions to terrorism and all that jazz. You know, we're not really -- I mean, you could say it's a good idea to improve the efficiency, but take a look at how we're not doing it, not even taking the central repository and kind of exercising that. So somehow that thinking has to change.

One other follow-on thought. If you're building an integrated circuit, you can get a piece of software that will eventually allow you to do that. Does that exist for the optimal grid? It would be a nice thing for the DOE to kind of put together. You know, let's try this. You put in a baseline case, here is New York or here's California, and let different people play with it.

Say, well, suppose we had 10 percent storage, suppose this amount of it was fast reacting and this was this, kind of a what-if kind of thing. So let's bring the tools together with the information sharing and kind of really address the challenge, just the way we would do anything else.

XXX: We have not done that to date?

XXX: Well, not only have we not done it, but we're kind of going backwards. We're islanding information, we're not sharing it. And -- I don't know. I mean, I guess I made that point.

XXX: I don't think the last statement is true, because there are two ARRA funded initiatives for long-term transmission planning, one for the western grid and one for the eastern grid. And the western grid, we are closely involved with that and we have seen how the processing works. The WECT (phonetic) is closely involved with all the stakeholders, the Western Governors' Association, (inaudible), and they have involved different entities who actually do this kind of planning and do it to systematically transfer, given the new available sources which are coming into the system.

XXX: You mean the new generating sources?

XXX: Generating sources.

And I don't think one should include the efficiency of the generation system as part of the grid. I really take issue with that. If you are talking about efficiency of the grid, it is only the transmission part of the available source to somebody who is going to use it.

XXX: I want to throw a datum in there. Some time ago I was wondering what is the cost of outages to utilities, actually to industry. And we commissioned the study at Berkeley, and the result was rather interesting because there were parallel studies at EPRI. It's at the order of $80 Billion a year cost to U.S. industry. Now, EPRI came up with an even bigger number.

If you take $80 Billion a year, that is very roughly one-third of the cost of electricity transactions in the U.S. So does this mean that 30 cents on the dollar are basically wasted? And these are not the big outages. It turns out the small outages, the momentary outages, seconds to at most minutes, are by far the more costly ones.

XXX: This is the cost to the user, not the cost to the utility? As far as I know --

XXX: To industry, the user.

XXX: -- when my electricity goes

out, my XXX doesn't go down.

XXX: But it's in terms of activity.

XXX: We won't discuss the utilities. Good.

XXX: I'm going to have to take issue with the gentleman here.

XXX: The other discussion --

XXX: If you think about the grid for a minute -- because it is not simply a series of wires and transmission lines and systems to operate; it's rather an enabling device to achieve larger social and economic, even environmental outcomes. To that extent it also includes things like attitudes, capability of the personnel to operate, real-time information to make critical decisions in timely ways, ways to enable a more robust and prosperous economy. To that extent the grid has enabling powers well beyond the simple wires and the computer and the controls that manage the system.

If we think of the grid in a limited way, then we may be foreclosing other options. So to that extent it does matter what the definition of the grid is. But I suggest we think about the grid as an enabling platform to achieve larger socioeconomic purposes. Then in fact our efficiency is limited at best now and we can

do much better.

XXX: I'm not sure I totally understand the efficiency argument. You look at wind generators, they operate at a lower capacity factor, their efficiency is lower, yes, they're an enabler to society of clean energy. So I'm a little lost in there. I thought I would throw that example out.

XXX: PV even lower.

XXX: PV even lower. We can get even lower.

XXX: So somebody whispered to me the comment during one of the breaks, you know, we worry a lot about efficiency, but if you look at roads, if you look at the Internet, the capacity of those systems is much greater than their actual use, and we tolerate that all the time. In fact, we desire it. So why should generation be any different?

XXX: Excuse me. I'd like to add that the problem is that you've got these huge external costs that we're totally ignoring. And then frankly all of the -- I think there are the unspoken -- I think the thing that's unspoken in this room is that there's a new urgency with carbon, with climate change, with pollution, with ocean acidification, with reaching climate tipping points that's driving all this. So that

when you say that, you know, the system is -- you know, that coal is more efficient than solar, is that really true? Because if that solar plant has to run three times longer, well, it doesn't have any -- you don't have to haul away the coal ash, you don't have a wall of coal ash that's going to come down. We have all these externalities we've effectively ignored for years that are so big now they can no longer just be swept under the rug. And so that is really a driving, driving force.

You know, here in sunny Arizona -- New Jersey put up three times more solar than we did last year. Germany put up -- has half the world's installed PV with a capacity factor that's far, far lower. Now, those people aren't going bankrupt in Germany. In fact, their economy is growing.

XXX: Actually, Spain is.

XXX: And the point, there are a few economies in the world that is growing. And Spain's was not designed very well. But there are external costs that we are in fact pretty much totally ignoring.

XXX: (Inaudible).

XXX: Louder, please.

XXX: I'm saying that it isn't so much renewable that's necessarily pushing the dirty technology out. They're pushing the -- most of the

marginal units are gas, natural gas burning units. So what we are pushing now is clean technology and leaving the dirty one. So it's not that straightforward.

XXX: I don't know if I agree with that. I mean, they're shutting down 900 megawatts of coal in Colorado and they're refiring it as gas. I mean, I think this whole system is, you know, pushing and pulling on different things.

XXX: I mean, we could price carbon, and, you know, we should. All right. So I'll give you $40 a ton, $50 a ton. I think the efficiency discussion still remains more or less independent of that. Whether the efficiency goes up or down, it's not obvious to me. Yes, you are bringing in renewables which have nominally lower efficiency, but you might start more efficient fossil plants to respond to the carbon price.

XXX: Well, there's also introducing a new norm of considering energy efficiency as a generation source and discussing it that way and communicating in terms of total life cycle cost and even including some of those traditional externalities that would be a reframing to address these.

XXX: So how firmly -- I mean, you raise an interesting point. We ran an efficiency workshop last week in Pittsburgh, as you heard. How firmly

embedded in this community's thinking or in the utility's is the notion that efficiency is megawatts more generally, right, but efficiency is the source of generation? I don't think we heard too much of that sort of thing today.

XXX: Firmly embedded in the Pacific Northwest. Firmly embedded.

XXX: Is that hardly or firmly?

XXX: The largest reserve we have is efficiency.

XXX: The largest efficiency, right.

Anybody else?

XXX: Just a comment about valuing externalities. And I do agree with that, but let's not also forget that there have been production credits and things to encourage sustainable global resources. So these are policy questions that haven't been lost on federal government to try to encourage these technologies so that they have an even footing with other technologies. So it's not -- I don't think it's totally lopsided, these issues that did sort of crop up.

XXX: Unless we don't have a price on carbon. Our specs are not great.

XXX: I don't really want to engage in the efficiency argument, but I kind of have to a little bit.

If you want to -- you can really look at efficiency several different ways. If you want to look at wells and wheels, wells can service efficiency. You have to take the system boundary, start behind the resource, go out to the point at which the customer makes use of the energy. And we could go back to gas lighting and use direct fuel and have, you know, half percent. The electric lighting efficient -- the efficiency of the use of lighting has improved throughout this time period, even while the power plants have remained relatively constant in terms of their ability for thermal energy, because the end-user's devices are improving.

XXX: That's the end-user's devices, is that --

XXX: Right.

XXX: Because the end-user devices --

XXX: Are more efficient --

XXX: Are more efficient.

XXX: -- in their usefulness.

If you take a look at the total system of efficiency on the economy, the use of increased Market share in electricity has tended to drive down the energy intense (inaudible). And it's difficult to create a theoretical reason for that, but it's because electricity (inaudible) innovation in the use of that energy. But we

could have that argument separately.

XXX: Has the total amount of electricity used for lighting gone up or gone down?

XXX: As a function of Market share, it's slowly climbed over the years. A little over percent.

XXX: Since the Market is going up, so the absolute amount of electricity --

XXX: If you look at the data on energy intensity GDP, that's continued to improve.

XXX: That I know. Basically our energy use has been constant over the last 20 or 30 years per capita, even as the GDP is --

XXX: Right. So the energy intensity per unit of domestic -- gross domestic product has improved, and that's because of innovation in the final user point.

Even though coal plants are no more efficient today than it was in 1960, the electricity system, including the user's device, has improved. Heat pump technology, marginal best available power plant gas fired onsite, 60 percent efficient. And COP of 3 heat pump technology, you beat a gas furnace.

XXX: So just one word on efficiency and data. I think, unless I'm mixing my meetings up --

and they all start to run together -- somebody mentioned the spaghetti diagram, the Sankey diagram, this morning, and the efficiency numbers in it. Actually, if you look at the three end-use sectors, not power but residential, commercial, and industrial, and look at the efficiencies assigned to each one of them, they are identically 0.8 for all three of them. And basically that reflects somebody's guess rather than any data. And again harkening back to a comment I made this morning, we just really don't understand. We don't have enough data how people actually use energy.

XXX: I was the one that mentioned that, and you're exactly right, spot on. It has been constantly 80 percent for those three sectors for a long period of time. Just take lighting as one example. Incandescent lighting now may be 8 percent efficient, fluorescent not much better. If you take furnaces, the stock of furnaces in the homes may be 65, 70 percent on average. So the 80 percent is already off. By the time we start working our way through all of those, we'll find substantially smaller levels of efficiency, suggesting it's constraining other resources in the economy. So we're not as productive.

If you look at the period 1950 to 1980, our economy grew at a productive rate of about 2 and a quarter

percent. 1980 to 2010, our productivity economy wise has fallen about a half a percent, about 1.75 percent. The economy is not nearly as robust in the last 30 years, and a lot of it can be traced back to not the efficiency as you measure energy intensity but the ability to uptake used energy, the energies actually at work to transform matter into goods and services that we value, and that begins to hold a different picture.

That's why I go back to the grid as an enabler. Unless the grid together with the management, the economics, social principles that guide our choices, unless that opens up widely we're going to be substantially constrained in those larger benefits we seek in economic well-being and national security and the like.

XXX: That's perhaps the right kind of comment to close on.

Well, great discussion. Again, every one of these -- this is now No. 4 -- has been different. Interesting. I think there has been great input as we prepare the QTR document and the technology assessments.

Exactly how we will continue to engage you all going forward I really don't have an answer to yet. As XXX already alluded to, we're making this up as we go along. And we know how to reach you. Our contact information is up there. And we will certainly be in

touch before this exercise concludes in the fall.

So thanks again for your help and participation, and travel well. Thank you.

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