U.S. DEPARTMENT OF ENERGY

Valuation of Energy Security for the United States: Appendices

Report to Congress

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Contents

Appendix A: Agenda and Transcript from May 13 Energy Security Public Workshop

Public Meeting: New Opportunities and Challenges in U.S. Energy Security

May 13, 2016 / 9:00 a.m. – 12:30 p.m.
U.S. Department of Energy Forrestal Building, GE-086 (Large Auditorium)

AGENDA

9:00 – 9:15 **Welcome and Introduction** (Melanie Kenderdine, U.S. Department of Energy)

9:15 – 10:45 **Panel 1: U.S. Oil and Gas Security in a Time of Relative Abundance**

The US oil and gas security picture has changed dramatically in the past decade, as domestic production of both fuels has soared, the share of oil imports has dropped, and the U.S. is poised to be a net exporter of natural gas. For different reasons, U.S. oil and gas producers now face a low price environment and demand changes increasingly driven by policy, and both oil and gas producers face challenges in siting and protecting infrastructure. Meanwhile, many other countries, including a number of close U.S. allies, continue to struggle with the intersection of oil and gas supplies and geopolitical concerns. Other countries—including a number that have historically had challenging relationships with the U.S.—are finding a new place in the energy geopolitical balance as the U.S. role shifts. And even in a time of relative abundance, a significant supply or price disruption is still feasible. What are today's oil and gas security challenges for both the U.S. and other key allies, and what policy solutions are most relevant to address those challenges?

Panelists:

- Kevin Book, Clearview Energy Partners
- Terry Boss, Interstate Natural Gas Association of America
- Leslie Palti-Guzman, Rapidan Group

Moderator: Sharon Burke, New America Foundation

At least 30 minutes will be available for questions from the audience and open microphone.

10:45 – 11:00 Break

11:00 – 12:30 Panel 2: U.S. Electricity Security with a 21st Century Fuel Mix and Grid

The U.S. electricity sector is undergoing dramatic change to its fuel mix driven by both price environments and policy, leading to new pressures on the traditional centralized grid model/infrastructure—and with increased reliance on electricity as a transportation fuel, U.S. electricity dependence will grow. New cybersecurity risks have also arisen as grid operations have become more complex and "smarter." How much do these factors—or other concerns such as solar flares electromagnetic pulses, or kinetic attacks—affect electricity reliability? How should private actors balance and prioritize these risks against other more immediate challenges to reliability, such as weather and other natural hazards? What policies should the U.S. be considering to further protect the reliability of electricity supply as the sector becomes increasingly decarbonized?

Panelists:

- David Brown, Exelon
- John Lawhorn, Midcontinent Independent System Operator
- Gary Rackliffe, ABB Group
- Curtis St. Michel, Idaho National Lab

Moderator: Mike Telson, General Atomics

At least 30 minutes will be available for questions from the audience and open microphone.

Public Meeting: New Opportunities and Challenges in U.S. Energy Security

May 13, 2016 / 9:00 a.m. – 12:30 p.m.
U.S. Department of Energy Forrestal Building, GE-086 (Large Auditorium)

TRANSCRIPT (lightly edited)

Welcome and Introduction

Andrew Stocking: Hello and thank you all for coming out. And a special thanks to our panelists, our moderators, and Resources for the Future, for all the help that they provided in putting this workshop together. It should be an interesting half-day.

This workshop is designed to be a discussion. Each panelist will give a five to ten minute introduction about relevant issues that interest them. Following that, we will open the conversation up to those in the room. There are lots of live microphones throughout the room, so we hope it'll be a pretty lively discussion.

To set up the conversation, though, let me first introduce Melanie Kenderdine. She's energy counselor to Secretary Moniz, and the director of the Office of Energy Policy and Systems Analysis, colloquially referred to as EPSA here in the building. She has served in several key positions here at the Department of Energy, and has a long history of working with Secretary Moniz, both here and at MIT. Most importantly, in July of 2014, she was named one of the five most influential women in energy by National Journal.

[Applause]

Melanie Kenderdine: Thanks, Andy.

Thank you all for coming, and let me first note the reason why we are here. The FAST Act included provisions that required DOE in collaboration with the State Department to produce a report that evaluates and defines US energy security to reflect modern domestic and global energy markets and the collective need of the US and its allies.

I first worked at the Department of Energy for the entire 8 year term of the Clinton administration and then returned with Secretary Moniz. Between those two services, a noticeable change had occurred with respect to how the department incorporates energy security and emergency response in its mission and function. The change was palpable when I walked through the door for the first time with Secretary Moniz. That has inspired us to define, improve, and enhance energy security and our emergency response function to energy emergencies.

I reviewed the Department's organic statutes a few months ago, and energy emergencies are defined as: "To facilitate establishment of an effective strategy for distributing and allocating fuels in periods of short supply, and to provide for the administration of a national energy supply." That is from the DOE Organization Act of 1977.

So fundamentally, the 1977 view of a key measure of energy security was gasoline rationing. I dare say that that is a fairly antiquated view of what we need to meet today's energy security needs. It was a very different time. I would note that this measure is still operative, and it is the only language in the DOE Org Act's purposes section that addresses supply emergencies.

The International Energy Agency's definition of energy security is more modern: "The uninterrupted availability of energy sources at an affordable price. Energy security has many aspects: long-term energy security mainly deals with timely investments to supply energy in line with economic developments and environmental needs, … and short-term energy security focuses on the ability of the energy system to react promptly to sudden changes in the supply-demand balance."

However, thus far, all of our collective actions and the insurance policy with IEA and members who work collectively with IEA are about days of oil import protection. That's more about 1977 global oil markets, which really weren't global oil markets at the time, and far less about today's oil markets.

Setting aside its existing oil-centric response mechanism, the IEA's actual definition of energy security is about enhancing the resilience and reliability of our energy infrastructure systems and components and is increasingly important. President Obama highlighted the fundamental need for resilient and reliable energy infrastructures in Presidential Policy Directive 21, in which energy infrastructures were described as uniquely critical, and as noted in the QER, the consequences of hazards to infrastructure broadly affect social welfare. They go beyond the ability of a system to operate and address the vitality of our national safety, prosperity, and well-being.

Maintaining energy infrastructure resiliency and reliability is as challenging as defining the metrics to ensure it, which is one of the things we are talking about today. The transformation of our energy landscape, dramatic increases in oil, gas, renewable energy resources, and exports of natural gas and oil, require new infrastructures. Existing infrastructures are not always well-matched to new sources of supply.

Our energy infrastructures are also aging. The gas main that tragically downed two apartment buildings and resulted in eight deaths in New York City a couple of years ago dated back to the 1880s. The imperatives of climate change and increases in extreme weather events strongly suggest we need to simultaneously harden and modernize our energy systems. These critical systems also face new and growing vulnerabilities, including cyber and physical incidents, and there is a growing interface between energy and IT systems. This could create new cyber vulnerabilities at the same time it enables real time responses to supply and demand, and helps improve systems operations.

In addition, our energy infrastructures are increasingly interdependent, and all are dependent on electricity, which I have been calling the uber infrastructure here recently. That's what we're working on in the QER 1.2 now. Hurricanes Katrina and Rita downed 85,000 utility poles, 800 distributions substations, and thousands of miles of transmission lines. On the worst day of these sequential events, the nation lost almost 30 percent of its refining capacity. Three weeks after Rita hit, oil markets were still short around two million barrels a day, demonstrating the interdependency of our energy infrastructures, how that needs to be a focus of how we are defining energy security as well.

We are making progress domestically and internationally. This is language included in the recently-passed 2016 Senate Energy Bill regarding energy emergencies. "To facilitate the development and implementation of a strategy for responding to energy infrastructure and supply emergencies through,

a) continuously monitoring and publishing information on the energy delivery and supply infrastructure of the United States, including electricity, liquid fuels, natural gas, and coal.;
b), managing Federal strategic energy reserves;
c), advising national leadership during emergencies on ways to respond to and minimize energy disruptions; and
d), working with federal agencies and state and local governments to enhance energy emergency preparedness and to respond to and mitigate energy emergencies."

That's a lot of progress compared to the section on gasoline rationing that I read in DOE's organic statute.

We also have the broad and collective definition of energy security adopted by the G7, focused on diversity of supplies, suppliers, and supply routes, the impacts of climate change, the importance of efficiency, and the need for collective action with our allies.

In addition, I note that the FAST Act for the first time provides authorities to act on cyber emergencies, noting that a grid security emergency now means "the occurrence or imminent danger of a malicious act using electronic communication or an electromagnetic pulse, or a geomagnetic storm event, that could disrupt the operation of those electronic devices or communications networks, including hardware, software, and data, that are essential to the reliability of critical electric infrastructure or of defense critical electric infrastructure."

I note these authorities are additive to the emergency authorities described in the Federal Power Act and the Defense Production Act. They're additive in two ways. First, this is the first time that cyber security has been addressed as a critical energy security need. And second, it provides anticipatory authority. We already have anticipatory authority for the strategic petroleum reserve, and this applies that authority to cyber events. Often, those are very hard to anticipate, however.

In closing, Admiral Mike Rogers, the NSA director, before the House Select Intelligence Committee in November of 2014, took energy security to a national security level. It's something that we are looking at in QER 1.2. And this is a quote from Admiral Rogers before the Intelligence Committee. "There shouldn't be any doubt in our minds that there are nation-states and groups out there that have the capability…to enter those industrial control systems and to shut down, forestall our ability to operate our basic infrastructure whether it's generating power across this nation, or whether it's moving water and fuel."

As we create a lot of new entry points to the grid with smart meters and electric vehicles and rooftop solar, which add enormous flexibility and help us meet climate goals, we're also adding vulnerabilities to our grid, and we need to be mindful of those as we are discussing energy and national security.

Last November, the Center for Naval Analysis noted that reliable electricity underpins every facet of our lives. The design of the grid and its inherent vulnerabilities are known to our enemies, foreign and domestic, which points to the importance of electricity. Although it is not mentioned as an emergency need in DOE's existing organic statute, it's a focus of our discussion here today.

I would like to thank Congressman Upton and others for their work on the energy security provision in the FAST Act. The resulting report will underpin efforts to modernize a lot of what we are doing in the energy space here at the Department of Energy, across the country, and indeed around the world.

Now I'll turn to the first panel that we're going to have today, US Oil and Gas Security in a Time of Relative Abundance. It will be moderated by Sharon Burke. Sharon is a senior advisor at New America, a think tank in Washington, DC. She has served in a number of senior government positions, most recently as the Assistant Secretary of Defense for Operational Energy. She started her career at the Office of Technology Assessment in the Energy Program, back when oil was even cheaper than it is now. And I'm going to turn over the panel to Sharon, and she can introduce the panelists. Thank you all very much for coming.

[Applause]

Panel 1: U.S. Oil and Gas Security in a Time of Relative Abundance

Sharon Burke: If the panel will just join me, we'll get started. All right.

[Background voices]

Sharon Burke: Well, welcome, everyone, and I'm delighted to be here. I think this is a very important conversation for us to have, and I'm delighted to be here with this group. So I'm going to introduce the panelists to you, say a few opening comments, and then each panelist in turn will give some opening comments and then we will get in some dialogue and bring in the audience, because I've noticed that we have a number of true experts in the audience as well. So that would be useful for all of us.

You should by all means look at the extended bios for these folks, but just a general introduction: what you have here are one person who's knowledgeable about the physical infrastructure, so the guts of the system, and then two very sophisticated and experienced market watchers who look at the commerce and trade side of energy, among other things. So we have a very complementary group that can talk about all aspects. Terry Boss, immediately to my left, is the senior vice president of the Interstate Natural Gas Association of America. Leslie – and I got to make sure that I get your name correct – Palti-Guzman, right? Because I practiced the pronunciation. Is the director of global gas at the Rapidan Group, which is a great consulting firm in this space. Kevin Book leads the research team at Clearview Partners, and is a very experienced energy market watcher and thinker, including as a contributor to CSIS, and their body of work as a think tank – thank you very much.

So just a few opening comments from me to set the stage. My last job in government was as the chief energy official for the Department of Defense, and Defense looks at energy security in some interesting ways. Obviously, DOD looks at energy in the geopolitical sense, and as something that is part of their mission space, both as it shapes the mission, where you might actually have to send troops, but also DOD, a major role for the Department of Defense is the free flow of commerce and public goods. And so places such as the Persian Gulf become an abiding concern.

And we did do a lot of work while I was there trying to understand what that risk profile was, because even now, when we're negotiating partners with Iran, they still have a habit of saying that they'll close down the Strait of Hormuz.

So we were looking at that kind of policy matrix, but also, the Department of Defense is a major consumer of fuel, about four billion gallons a year. And the fuel is mission critical: the military cannot operate without it. The Department of Defense buys about 60 percent of its fuel overseas, so they're very much an international market consumer. They also are a consumer of commercial systems within the United States and in certain fixed locations like Korea. This includes about a $4 billion a year electricity bill, almost all of it coming from the commercial grid. There are a couple of plants that are owned and operated by the Department, but that's very rare in this day and age. So the systems' vulnerabilities are their vulnerabilities. The Department is both a consumer like any other consumer, and also a consumer with unique and in some cases, extreme energy security needs.

So I thought it was very interesting in the run-up to this, looking at the way the G7 defined energy security, because I feel the definition of energy security tends to be a little bit elusive. My favorite definition I ever had was from a scientist who worked for the Public Utilities Commission. I asked him how he defined energy security, and he said: "You know what? Energy security is when at the end of the day, my governors have a cold beer and a hot shower." So it's all in the eye of the beholder, but it's also generally about reliability, affordability, and sustainability.

The G7 principles are interesting, too, because they struck me as more about *how* you get energy security than what it actually is. So I think this is a great conversation to have.

I wanted to talk in terms, again, of how DOD would look at it. We would look at energy security in terms of asset, vulnerability, threats, hazards, and risk.

As an asset – energy infrastructure is a massive asset. This is a global system that starts at the wellhead and ends in somebody's gas station or vehicle or home, and that is a massive amount of infrastructure. So, this asset is absolutely enormous, and that's important when you look at vulnerability. This is an asset, a system of assets, that has many, many vulnerabilities, lots of choke points, lots of single points of failures, lots of inputs. So a massive asset that it's almost impossible to value fully, lots and lots of vulnerabilities. And then the next part of the equation is threat or hazard. So what are your threats and hazards?

It's really important when you're talking about something like this to be clear about all of this, because it's just not possible to make a system like this — that is so massive and so valuable — robust to everything, to every hazard and every threat. Not possible. It would be prohibitively expensive. So you have to bound the question. You have to understand the vulnerabilities and you have to understand the assets — which parts are most important or most critical for running our entire economy and our defense? You have to understand the vulnerabilities: where are the vulnerabilities? Which ones are most consequential? Not all vulnerabilities are created equal. And you really have to understand the threats and the hazards.

And that all adds up to risk, which is also part of the energy security valuation, because, again, you can't be robust to everything. So you're going to have to do some risk analysis. And I know some people don't believe you can appropriately analyze these risks, because that doesn't adequately account for the pace of change and for emerging threats, but you don't have a choice, because it's simply not possible to be robust to everything.

When it comes to defining the threats, if you were going to build a matrix, on one axis you might say: vandalism, insider threat, criminal threat, terrorist threat, and nation-state threat. And in considering that range of threats, you used to be able to qualify them in terms of prevalence and consequence, So vandalism is a very prevalent threat. There are lots of little vandalism acts of all kinds. And if you add in the means or kinds of attacks, this may range from cyber to kinetic.

But there are other kinds of threats, as well, and that matters when you are considering how to defend against these threats. There are insider threats, for example, and these used to be prevalent but low consequence kinds of threats. And then there are criminal threats. I would say, for example, in Mexico right now there's a problem on pipelines with narco traffickers having a sideline business of tapping into the pipelines. That's a criminal threat to their system, and it's prevalent but moving toward being a higher consequence event.

So then there is the terrorist threat, which is multifaceted in many, many countries and may be prevalent or consequential or both. And then there are nation-state threats; historically, [energy infrastructure] has always been a target in a time of war. Energyis what the military calls a center of gravity: your economy, your military, nothing can function without it. So if you're attacking somebody, you're going to attack their energy infrastructure. That is going to be less a prevalent threat but a very high consequence threat.

What's interesting about that matrix of prevalence to consequence is I think it's not as clear as it used to be. Vandalism used to be prevalent, but vandals really couldn't do high consequence attacks. But the lethality that's available to all of these actors is shifting, both in terms of weapons and then cyber tools, which I think we'll hear more about in the next panel – and also Terry, I think, has some insights for us on that. The potential lethality at all levels of this threat matrix is changing. That sliding scale between prevalence and consequence and type of threat is no longer clearly a spectrum moving from vandalism to nation-state.

So I think the threat analysis and understanding the threat is a really important part of bounding the problem in a credible way, particularly as that threat matrix is shifting, so that where nation-states used to be the only ones that could really mount truly lethal attacks, that may not be true anymore. It's important to understand that.

For hazards, also, the hazard picture is shifting quite a bit. So we have environmental hazards, and that can range across all kinds of things, including methane leaks and disposal water for fracking wells in natural gas operations. Changing natural hazards would include extreme weather events, and I know DOE is looking at this, and the fact that that picture is changing. Natural hazards are also obsolescence, lack of maintenance, age of the system, as well as the interactions of all these factors. And then there is market hazard, which I think we'll get into quite a bit more in the panel discussion.

So in the high price environment, there was a lot of market hazard for the United States and other consumer nations. In the low price environment, there's also a lot of market hazard, for consumers and especially producers. And we can see it in Venezuela, in Nigeria, the countries that are sort of "dead country walking" almost at this point. And what is that going to mean for the global markets and for prices at home? The Kingdom of Saudi Arabia has made some very interesting, bold statements about diversification, about privatization, but those things also come with a lot of risk for them — political risk and economic risk. They're involved in military adventures, which are expensive at a time when the Kingdom can't afford that. And what does that add up to? And can the world afford a Kingdom of Saudi Arabia where it's not just political turbulence at home, but also a global market effect?

So I think there's a lot of risk in the market right now, a lot of hazard. Risk and hazard in this context is always a little interesting. I think probably market watchers would describe it as market risk, but in my world, I would call it a hazard, but it aggregates up to a risk for our economy.

I also think there's some interesting demand side risk, and I would not be a responsible defense professional if I didn't say the word China. China's demand risk – it's multifaceted. When their demand is low, it's a market risk. When their demand is high, it's a market risk. The relationship between Russia and China and production agreements and now China possibly becoming a part owner of Rosneft – what does that mean when those countries draw closer? As a defense person, that concerns me greatly. It concerns me for the long haul, and the fact that the Chinese are looking at long term supply security as a government responsibility, and we're looking at the market to provide supply security. And to me, that in itself is a risk. You know, can we be sure that we're going to have fully functioning markets ad infinitum?

So those are some opening comments for all of you, and now it's our panelists' turn to make opening comments, and we'll get in some back and forth. Terry, would you like to get us started? And please, add anything else about your background that you want to say – or just talk.

Terry Boss: Should we talk resiliency or surety? That's a joke for Melanie.

Sharon Burke: She's laughing.

Melanie Kenderdine: _____ surety.

[Laughter]

Terry Boss: Yeah. It's a constantly changing environment, and probably of all the years that I've worked in this industry on the natural gas side, it's probably the most challenging time that we've ever had. And a lot of that is because of the culture that's involved now. It's – people's expectations out there. They would like to have everything if they could. And it kind of affects – it depicts kind of the political environment that's going on right now, and that is a challenge, because a lot of the infrastructure that we've got out there and what we're trying to develop is based on certain paradigms. And as those paradigms change over the years, obviously, the industry, the assets, have to change to match those up. The introduction of renewables into the infrastructure, the introduction – the impact of what's happening with coal, has a big impact on that. And then, obviously, the use of the internet and computers and so on like that have a significant impact.

So I would argue that one of the challenges that we're having, and where DOE fits in here very nicely, is that with all these challenges coming on, they still have the mandate on energy to understand how it does impact on that. And so as Sharon was mentioning on that, we're dealing with a lot of different fronts. We'd like to achieve a lot of environmental goals that folks are looking, trying to do. At the same time, we've got public safety goals that we're trying to do, and personnel safety goals as we're moving through these things. And then the rise of additional security threats out there at the same time.

Sometimes they're at cross-purposes. Information sharing that goes out on the market to help the market work sometimes gives a very good view of a good place to attack, if you're going after a security event. And vice versa, if you're trying to get transparency on environmental performance, that information gives an idea of where some impacts are.

The other thing that is probably very compelling is the rate of information transfer and communication going on right now. Things are happening so fast, and the communication is happening so fast, and people are expecting information to be there, and they're reacting very quickly to those things. And a lot of our systems aren't necessarily built and cultures are not built to react that quickly as we're trying to figure out what's going on.

So in a lot of cases we've got virtual crises going on, because we're lacking information of what's going on on those sort of things. We just got done with a tabletop exercise where we were trying to simulate an industry-wide attack on the natural gas transmission industry. And the interesting aspect on that was that we were attacking essentially the virtual business systems rather than the physical flows that were going on, but there was enough crisis being involved because people thought things weren't quite happening the way they were, but the physical flow was really going on, but the business was disrupted. And so it's a matter of what folks' understanding of the crisis is out there.

But I think that's probably the biggest challenge to do, is to weigh and balance all the things that are going on right now, and try to find that balance, to achieve where you want the US and North America to be very good, but it is a challenge these days, because everybody's trying to optimize their own little kingdom, you might say, on these sort of things, and putting these things together. So I'll stop there.

Sharon Burke: I was going to ask you one follow-up question. So in terms of the physical systems, the distribution systems that you follow, how concerned are you? How robust is that infrastructure? Can you identify the choke points, and the vulnerabilities that are consequential? And is it affordable to start making those more robust?

Terry Boss: It's an interesting question, because obviously, our market is changing as folks rely on more natural gas for electric generation. You could make arguments renewables are coming in there, but we do provide peaking type services on those. And it's a little bit different service that's being provided for those type of needs on the customers. And contractually, we provide transportation services, but the value of resiliency and reliability has to be built into the market, with enough lead time, so that people can understand there's a value to that. And sometimes it's very hard to value resilience and build it into a market that's thinking a year or two years ahead on some of these things.

And so that's probably the real challenge in, you know, the American manage the crisis when it happens type of effort does work sometimes, but that's probably the biggest challenge, is to realize what the new market is and be able to perform in that kind of market, and in order to do that, we have to articulate, simulate, communicate what the risk is out there on resiliency, and to be able to price that into the market, so that folks can be ready for it.

Sharon Burke: So what are some of the ways you do price it into the market? How do you calculate it?

Terry Boss: The – obviously, we've had a big change going on, and it's really – I wouldn't say we fell into it, but the supply diversity, because of the research that had been done in new techniques with shale gas and stuff that has been going on, actually diversified the supply quite a bit, so that the resources of the supply are very diverse right now, were essentially an infrastructure of interstate highways that – some highways are used more often than they were before, and others aren't. Obviously, we're trying to build a lot of facilities to accommodate some of the new supplies, and that does give us a lot of diversity, including storage.

But then the expectations, again, of – you want to call it NIMBY-ism or something like that, where people expect their little place in life to stay the same, not to have changes like that. We do impact people if we have to build a pipeline on something like that. So trying to impart societal goals to individuals is very difficult. And obviously, we're a very democratic society right now, and it is hard to essentially convince somebody that somebody knows better, to do these sort of things. So building pipelines to cover that, obviously, we've got a lot of storage.

Talking from one industry to the next, that's what happens on a lot of these interdependency discussions, is that somebody understands their industry and what's going on, but you really don't understand the other industry. And all of a sudden you say, hey, I'm depending on you. What do you have? And make it fit my idea of what dependency is. And that's a very big challenge, talking from industry to industry on those things.

Sharon Burke: You'll hear sometimes in the chatter that the sort of fast ascension of natural gas is a single point failure. How do you respond when people say things like that?

Terry Boss: Well, the – obviously, if you have a failure in the pipe that's coming to your house, it's very quick and instantaneous. But the natural gas system is somewhat archaic. Its physical movement, all gas is pretty much the same, so from a business standpoint, you may be buying gas today, but you – in Louisiana, but it automatically gets delivered in New York at the same time. So it's very fungible.

Also, it moves 15 miles an hour. It's compressible. So there's a built in inventory structure to the natural gas system on that. There's limits to that on those sort of things, but that does give us a lot of flexibility.

One of the challenges that we have is a lot of folks would like to take that flexibility and utilize it themselves rather than using it as a resilient type function out there. So there's a lot of attempts to skim the efficiencies off the top of the system.

Sharon Burke: Can you explain what you mean by that?

Terry Boss: Well, if – if systems were not as robust, and the cold front came in quicker than you thought, you had some flexibility built into the system. But if somebody said, boy, I'd like to have that flexibility. Can't you just sell it to me so I have it? Then all of a sudden it's not available. So the people that thought they had the ability to take the resiliency that's out there, versus that building sold off as the market on that, that's a challenge on that, and people have different beliefs on that, and what they are willing to pay for those sort of things.

Sharon Burke: Thank you. Leslie, that's a great segue. So: flexible, fungible, archaic, fast, growing, rising. Now talk to us about the global market there. And I'm going to seed a question for you that you may answer when you wish, or not, but certainly from my world, if I were a terrorist, I'd be really interested in LNG terminals. So there's some interesting vulnerabilities in this space as well.

Leslie Palti-Guzman: Yeah. So let me give you a little overview of the global gas market. Like there is really a global gas – a new global gas order, and what it means for US LNG exports and the geopolitics of gas. So the two maybe most important developments this year in the global gas market are an unprecedented growth of new LNG supply capacity, notably from Asia-Pacific, and the first exports from US shale to LNG, to anywhere around the world.

And those two developments have put a spotlight on this new gas order that we've seen emerging since the second half of 2014. And some of the few characteristics of this new gas era are an increasing fragmentation of the gas market with more intra-regional trade, but also a more diverse set of players, huge demand uncertainty, third, lower prices, both on long term contracts for gas and on spot prices, greater amount of flexibility with a larger amount of flexible supply, versus long term supplies stuck into long term contracts, and the growing competition between exporters.

So those developments have led to speculation about the opportunities and obstacles for US LNG exports. They are bursting into a glutted market. And so what does it mean in terms of also geopolitics for this new role of US LNG exports? US LNG is all about flexibility. They are not bound to any destination, and that's – that contrasts a lot with the vintage oil index, long term contracts that many Asian players have, where the cargoes were bound from point A to point B.

Here, the US LNG cargoes can go anywhere, and second, the purchasers of US LNG under long term contracts can, with some notice, decide not to export the cargo. So it means that US LNG with its own unique characteristic is going to bring into the global gas market a lot of flexible cargoes that will be easily divertible and flexible. So it's going to create more opportunities for swaps and trade operation and growing efficiency in the global gas market.

For now, if you think about it, Qatar is the exporter that remains in a way the swing supplier. And post-Fukushima, Japan needed extra LNG, and Qatar was the only supplier that was able to mobilize ten extra million tons of LNG to Japan, because they had this amount of spare capacity, in a way.

But the US is likely to assume in the future this role of swing supplier, which is going to stabilize the global gas market in a period of supply or demand shock. And US LNG exports are likely to adjust themselves in terms of production, depending on the need for US LNG. So if there is a need, a world need for additional LNG, US LNG will be there. If there is a low demand point, US LNG will produce less, or not export.

Also, the US will be this kind of emergency go to supplier in time of crisis, and here is the example of post-Fukushima, if another big disaster happens. So in a way, US LNG will further liberalize the global gas market and provide a safety net.

However, and that's a big but, is that all that comes true, but only if the US LNG sector can find a way to sell its products. So US LNG needs to sell, and here, I'm talking about demand security. What is the medium term and long term demand for LNG? That is the most critical element to watch in determining whether the world needs US LNG.

And the world post COP 21, I think there is a lot of momentum for gas versus coal. But again, price matters. In many countries, China, India, Southeast Asia, LNG gas competes with other fuels. And so gas and LNG will have to remain competitive.

There are some reasons to be optimistic. More affordable and accessible LNG has created renewed or new appetite in several countries. Think about Jordan, Pakistan, Egypt. They are all new LNG importers for less than a year or a year and a half. And it makes also – this new, more affordable LNG creates a case also for the environmental argument of coal to gas switching.

Also, this over-capacity in the global gas market creates lower odds of geopolitical disruption. In the near-medium term, current structural LNG over-capacity mitigates the risk that one isolated geopolitical event can disrupt LNG flow. Like for instance, this year, in 2016, I don't really see any major isolated geopolitical disruption coming from one supplier. What can be interesting to watch is whether several disruptions could happen at the same time, and cumulated, would that matter for supply and pricing? But that, again, if you think about it, there are three countries right now that have shut down or idled their liquefaction capacity, and the world are not really missing it, and it's Yemen, Egypt, and Angola.

So for the past year and a half, or even two years, those facilities have been not producing LNG, and the global gas market has not even noticed that, in terms of pricing, at least.

So longer term, we see the emergence of the US, Australia, Canada, as potential large future LNG exporters, or exporters in the making. And that will reduce efforts by traditional suppliers to establish a cartel or exert their dominance to put pressure on prices. And potentially, OECD LNG exports by 2020 could reach nearly 40 percent of the global gas export market versus 15 percent in 2015.

So if you think about a key market that the US is very concerned about, which is Europe, I think Europe would be a big beneficiary of US LNG. US LNG will serve as a backup for European supply security. They see it as an option, as a way to improve their diversification of supply and put downward pressure on gas prices. It's never going to be – LNG in itself is never going to be the baseload supply in Europe, but it's going to provide momentum to further integrate their energy policies and increase competition to the market.

However, Russia, which is still the dominant supplier in Europe, cannot afford to lose ground in this core market, and especially now that Russia is experiencing a kind of post-honeymoon hangover with

China, in terms of its _____ to exports to Asia, Russia is in a way desperately trying to sell more gas into Europe and to not lose market share. So you may have heard a lot in the press about this price war happening in the European gas market, and that's a reality. This is happening.

And so the longer term role of US LNG in Europe is not to be taken for granted, because US LNG has to win the hearts of European utilities and consumers, and constantly offer competitive pricing, reliable deliveries, and now environmental friendly exports. I don't know if you heard, but this week, like the French Energy Minister decided that she would investigate on the ban of US LNG into France, so that is something – even if – I don't think legally it can happen. It'd just like gain a momentum in some green minds.

And here, I want to discuss a little bit this new notion of energy security that LNG brings, versus land pipeline. So LNG provides a different notion of security, and I think that consumers, utilities, governments, are not yet trusting this new notion of energy security, whether it's in Asia or in Europe, for instance, because there is no guarantee that US LNG would still flow into Europe when prices rebound in Asia, and then US LNG exports regain their competitiveness in Asia.

How Europe can still attract cargoes? Right now, it's not really a question, because the market is so over-supplied, that suppliers need Europe as their comfort market. But let's say we are in another cycle of tightness, and prices in Asia are much higher. The European Union, European utilities, have no guarantee that the LNG cargoes will still flow into Europe. So how do you provide this notion of energy security that – you know, compared to a land pipeline, it's a different notion, like the pipeline is a marriage, and to have psychologically this big pipeline infrastructure in front of you, you kind of think that it's more reliable.

So I think a functioning gas market, the right price signals, can become attractive enough to draw cargoes into Europe, and because the market will remain well-supplied well beyond 2020, I think there will be enough cargoes for Europe, Asia, and the rest of the world. But again, the market is becoming more competitive, but there are still efforts to be made to make it even more liquid and transparent and efficient.

So just to conclude, there are definitely very important geopolitical benefits that US LNG can bring, and many people have wrote about it and talk about it. To temper this optimism, it is important to keep like a few maybe limitations or risks or hazards in mind. And one of them is on the supply side, the success of US gas exports hinges on the fact that supply will remain constantly – that there will – there won't be any disruption to supply. And it means for the US market that there will be always a social license to operate. And then there are growing environmental concerns that need to be addressed.

Another risk is that there are always disruptive technologies happening, so how long will gas serve as a transition fuel in the US and abroad? The current pricing environment, so, you know, oil prices below $50.00, _____ _____ US LNG has lost some competitiveness, so how that in the future we need to look at oil prices compared to gas prices. And another risk is the weaker investment outlook worldwide, and what does it mean for the future decision of new LNG export decisions beyond the ones that have already been sanctioned?

Also, a growing convergence of regional prices between the US prices, the European prices, and the Asian prices, means that the economics of US LNG can be squeezed, and nobody knows for how long.

And finally, the US power to influence the shape of the global gas market can be jeopardized if there is a perception that the world energy market is controlled by the Americans. And just before – like last night, I was looking – I'm French, as you can hear with my accent. So I was looking at lot into all the comments that have been made in French on TV, radio, newspapers, about the last comment of the Energy Minister about the ban.

And I was very shocked – I mean, so many people that talk are not really energy expert or whatever, but I think there is right now in Europe this big geopolitical perception that there is a growing competition between – it's either Russian gas or it's US gas. And it's a political choice. And when you sit in the middle in Europe, it – you know, there are questions that they are discussing. So just some food for thought and for a discussion later. Thanks.

Sharon Burke: Great. Thank you very much. A couple of quick follow-up questions for you. With what you were describing as a growing intra-regional market, is there a risk of price volatility that we've seen in oil markets becoming a challenge?

Leslie Palti-Guzman: So for all the long term oil index contracts, especially still in Asia that remain fully 100 percent oil indexed, they move along with oil prices. So as oil prices become more volatile, those long term contracts in Asia will become more volatile. But you see a huge push from Asian buyers, Japan leading the pack, but also Singapore, China, rethinking the pricing formula for those long term contracts. And they are all pushing on their own, for their own LNG hub or LNG and gas hub, to establish a more – gas pricing mechanism which is based on supply and demand fundamentals, rather than obsolete oil indexation system.

So it's taking more time in Asia, but I'm really confident that it will happen. The same way in the US you have pricing around the Henry Hub, in the UK around the NBP, in continental Europe TTF, and other gas hub indexes, in Asia, you will see the emergence of several hub indexes, and that will – I don't know if it will be less volatile or not, but at least it will provide a diversification of pricing exposure. And when you talk about it to Asian buyers right now, what they want is not to rely solely on one index, which is still oil indexation, although many buyers have bought into US LNG to actually diversify further their pricing exposure away from oil indexation.

So potentially by 2022, Japan will have 20 percent of Henry Hub indexed in its portfolio, and then they are hoping to have an Asian index. So then they diversify their risk exposure.

Sharon Burke: But you talked also about price convergence. Does that also sort of spread the risk? Share the risk?

Leslie Palti-Guzman: So the whole LNG business is based on the pricing spread between markets, because you need to cover your liquefaction costs or transportation costs and your re-gasification costs. So the more the prices are converging between Europe and the US, the more the margin for the exports are squeezed or – they can say, okay, we're going to look only our short run marginal costs. Let's forget about _____ costs and let's optimize everything. But still, you need to cover some of the expenses, and recover the costs that you put into the infrastructure development, and so on. So – yeah.

Sharon Burke: Terry, do you have an opinion on that, on the price convergence and the exports of LNG, what it means for domestic gas security?

Terry Boss: Well, there is a relationship, and we saw that very much probably the past six or seven years, relationship between the oil and gas. Just because of the price of oil, a lot of the gas production was coming – co-produced with the oil. And so when we were doing some of our economic reports to see the impact, we actually had to model the oil infrastructure to see what was going on with that infrastructure, if it would move the liquids away on that side, therefore the gas production would come through.

So it's a complicated type relationship between – it isn't just a gas market and a liquid market. Sometimes they're tied in very close, unless they go with a completely dry gas market. So it's an interesting combination of those.

Sharon Burke: All right. Kevin, take us away.

Kevin Book: All right. Oh, you've both given me microphones.

Sharon Burke: All these microphones.

Kevin Book: One of the things I'll say just right at the outset is that we're in a world right now where oil inventories are masking instability all over the world. That's been true for a long time. It was true when there was a succession event in Saudi Arabia, and the oil price barely budged. You saw $1.00 a barrel. That was usually good for a couple of bucks, two or three, in even the weakest of economic times. You saw the capture of US Navy sailors by Iran, and the Brent price fell.

The oil price formation that we pay the most attention to really has two components, the production system and the stocks. And right now, it sounds like we're running flat out, if I tell you that the oil production system is running at about 96 percent of total capacity utilization. But when you take consumption in the numerator, how much we're using worldwide, and put it over supply as it exists today, plus spare capacity, in the denominator, that's actually pretty loosey-goosey. That's a very slack sort of production system.

And when I tell you that the inventories are now carrying 300 million extra barrels of petroleum in the OECD alone, you may say, what is 300 million? Well, it's about a full long weekend of production that doesn't have to happen that's sitting there that otherwise wouldn't be there, to buffer instability in the world, in the supply system.

The point, though, is that oil is part of an energy system. I think as Terry mentioned, as Sharon got to, and certainly as Leslie was discussing with global trade in gas, and in systems, the greatest vulnerabilities aren't just at either end of the system, but in the throughput in the middle. Sharon mentioned single points of failure, choke points.

If you're an environmental activist, your goal is to interrupt system throughput, and it's not necessarily – so you don't have to cut off all of the – you don't have to get rid of all the inventories in the world or all the production in the world to create a problem. You just have to get in the way of the transit of the energy, or not to be overlooked, the transit of the waste, right? You can't product oil without actually disposing of the byproducts of that production, not just the gas that must be captured, increasingly, rather than flared, but water that must be disposed of. Petcoke is a byproduct of fuel, also, but a byproduct of refining. You have to have a place for it. Sea lanes and terrestrial routes have to be available, and disposal mechanisms have to be available for the waste as well.

So if you think about disruption risk to the system, it's probably not sufficient just to look at what's being priced. In any case, market intelligence and media consolidation have left us in a world where nobody's looking at the Middle East right now when they look at oil prices. By all appearances, it's as if there's nothing going on. But if you were to set up a risk dashboard and say 2005, just pick a neutral year, like a good peak price year, kind of year, and set out everything you think that could be a worrisome thing about the global supply system, every light would be red today.

So inventories are indeed masking instability in terms of price discovery. The problem is that as our production system capacity utilization rises, which it will do when consumption recovers, we will get to a point where instead of being on the slack of a hyperbolic curve, we'll be on the steep end. And very small changes in production system availability will suddenly produce very large price responses.

This has always happened before. It'll probably continue to happen again. It's not a guarantee. There are not guarantees in economic analysis, or for that matter politics. But it's a good expectation that by the end of 2017, and certainly by 2018, we'll be in the sort of 98 percent range of capacity utilization, particularly because there isn't a lot of spare capacity in the world right now. The Saudis are running flat out, and the spare capacity that's available, if you want to call it that, is really a function of disruptions that can't necessarily be remedied. It's not exactly spare, the way something might be a spare tire or spare anything else.

And because we in the United States have a private energy industry, we have lean inventories. Lean inventories are essential to the efficient deployment of capital. So if you think about why, it's pretty straightforward. There's an opportunity cost for tying up money in inventories, and of course, there's – at any discount rate, you're going to build in some risk that you wouldn't have anything to sell at all, and you're naturally going to be very worried about that if you're in the fuel retail or refining or production business.

But you're going to also face a certain amount of risk from investors who are skeptical that you're misallocating their money. So shareholder concerns of privately owned companies discipline you to keep inventories lean.

Okay, so energy security in the US doesn't just come from the supply side. It comes from the consumption side, just like everywhere else in the world, and diversification obviously provides many opportunities. There is I think an artificial illusion of energy efficiency that we may be having right now. On the other hand, it's going to start to come true, especially on the roads.

I say it may be illusory, because our energy intensity of GDP has fallen far faster than intuitively it probably should have done. If you look at our energy intensity of GDP, and you say, wow, we've really gotten much more efficient in the last five years, it looks that way based on the math, but it doesn't look that way based on the infrastructure. It takes about 10 or 15 years to really cycle most of the appliances, buildings, and fleet that we're talking about to get that kind of change.

Some of this may be behavioral compression – essentially, people doing less with less, and to some degree, doing less with more, because they remember less, after two transportation fuel price spikes in the last decade.

What we do have, though, is a lower energy exposure in terms of our incomes. Other than diversification, you can create energy security by lowering your economic vulnerability to energy. Part of the way you do that is through efficiency. Another way you do that is through having more money. So if you look at the energy share of personal consumption expenditures, PCE, it's been falling by about half a percent every 5 years for the last 15 years.

Of course, the biggest part of that energy PCE is still gasoline, about 57 percent of it, and so that's why it's top of mind for everyone. Interestingly, even though Americans are buying huge cars as fast as they can possibly buy them, it isn't likely that we're going to see much more gasoline demand growth, because of fuel economy standards put into place by the Obama administration, and ultimately phasing in in about 2012, we're going to be, in 2017 or 2018, probably at or near the inflection point where demand starts trending down, because our fleet cycles out the old inefficient cars. Even if the new ones are trucks, even if they're not as efficient as the fuel sippers EPA may have imagined, they're still four or five miles per gallon in many cases, in some cases ten or fifteen, miles per gallon more efficient than what they're replacing. And the rest of the fleet will go dormant, go to the scrap yard, or go somewhere else.

So we're building in a certain amount of energy efficiency resiliency, just as a function of what we have. But can shale come to the rescue before we become perfectly indemnified against energy or oil price risk? There is I think a perception on Capitol Hill, based on what they've done with the SPR in the last several pieces of legislation, that yes, it can.

And there is a reason why you might think that. If 4.5 or 5 million barrels per day of incremental production can come out of the ground in the space of about 7 years, you have what looks like a very responsive supply system. On the other hand, there are mistakes analysts make all the time. I make most of them most of the time. But you can all make some of them some of them if you'd like. And one of the biggest ones is not knowing whether you should choose the most recent events as a proxy for the near future, or the whole of history.

Let me give an example. Oil prices since their inception as a transportation and commercial fuel in the middle of the 19th century on a real basis average about $35.00 a barrel. Okay? That's a very volatile pathway over the course of a century and a half.

If, on the other hand, you look at the last five years, they average about $95.00 to $98.00 per barrel, and that is considerably above where they are today. Which of these things is the right proxy? Should you be looking at the whole of history or the last five years? The problem is you don't always know, but it's important not to mistake a one-time effect or a one-time event for a repeatable phenomenon. It's also not very good to overlook circumstances that facilitate rapid growth. When economies have slack capacity, you can have job growth in specific sectors that might not otherwise occur.

So one of the things that is happening now in the oil industry is very similar to what was happening in the oil industry seven years ago, which is that there are significant job reductions.

And you ask, well, yes, but how responsive is this industry to a change in price? And I have a five year elasticity, because I love to compute numbers, of the energy jobs in America to price, looking at first the oil and gas industry, and then also the services industry. For those who think about oil elasticity, which is probably 1 or 5 of the average 100 people in Washington, but probably closer to 95 of the people in this room, you're probably thinking of a negative number for oil in response to price, probably like a negative .1 or maybe a negative .2.

So as a sense of magnitude, I want to give you first a sense of what shale did over the five year run. Shale, the seven shale regions EIA tracks in response to the Brent price, looking at a short run elasticity, is about a positive 0.5. So essentially, with price rising, it was very responsive, five times more responsive than global consumption tends to be, and almost twenty times more responsive than the production system has been over a similar interval.

The services sector, the oil field services who do the drilling and who are there to theoretically close the gap when the price signal comes calling, inventories narrow, and shale comes to the rescue, is also very responsive relative to say that .1 of magnitude of global consumption, about a .2 or even a .3 in some cases. The oil industry itself is much less responsive, .05 or so.

And if you think about why that is, it's because the core company staff are hired and fired reluctantly, because you don't want to take on fixed investment – again, shareholder-owned companies, that sort of thing. And you contract out for everything you can on a marginal basis.

But what's different now than it was seven years ago is that the US economy is at five percent unemployment. And yes, you can talk all you want about the labor force participation rate, and it's meaningful. It's not something I'd ignore at all. But if you go to Houston and you ask, where are the people who used to sit at these desks, the answer is they aren't doing something they don't want to do until they can get their oil jobs back. Some of them are, regrettably, yes. But many of them are being productively employed in chemicals and manufacturing. Many of them are being redeployed to sectors that are close to or exactly able to employ their skill set without necessarily being attracted back at the first rise in employment in the services sector from which they've so recently departed.

This suggests that if you look at shale's responsiveness on the way down, and it was not particularly responsive – we all know this now. For a variety of reasons, it turns out that US shale production lagged the price break somewhere between six to nine months before it even moved at all in most of the formations. You might not find that shale is that responsive to the upside, either. It may turn out that these system throughput issues, including people the people who are part of your system, get you caught up, it may turn out that the parts of the rigs that have been essentially scavenged so that no new fixed investment had to be made, won't be there when stacked rigs are brought back online. It may be that the drilled, uncompleted well inventory that is supposed to come to the rescue faster than any other part of US supply may not actually come to the rescue quite as fast, because companies, wary of their investor perspectives and their growing debt burdens, may not eagerly try to redeploy capital to that, if they have coupon obligations or other financial costs they have to address.

So that brings us to what do you do for energy security? And Sharon, you alluded to it. You have a big, huge inventory somewhere that you can tap in case of an emergency, and we do, luckily, in the oil system. Here in the US we have 700, 695 million barrels of crude. At $50.00 a barrel, it's worth call it $35 billion in sort of nominal terms. That's a lot. That's pretty valuable. But its insurance value, if you look at sort of the cost of not having oil as about $11.00 per barrel for every million barrels taken out of the market today, it's closer to about $160 billion.

So you're not going to probably capture all of that if you dropped it on a market that was under-supplied. Let's prorate it for the heck of it by 75 percent. Let's call it $37 billion, so effectively what you would get for selling it.

The thing is, the premium on that investment is actually quite small. You're paying $200 million a year in carrying costs. Throw another $200 million a year for – amortized over 20 years for the modifications that are being made. You're talking about $4 billion, even if it were $8 or $10 billion, to have that kind of coverage, would still be a pretty good deal in a world with this much instability being masked by inventories, and just on the precipice of being taxed on the production system, too.

So what am I saying, in sum? I'm saying three things. First, lean inventories create risk of their own, and we have government intervention to product against supply risk in that case. Second, inventories are indeed masking instabilities, significant instabilities that are in the world today, many of which would have moved markets by $5.00 or $10.00 a barrel just a single event 5 or 6 years ago.

And third, we have an increasingly resilient consumer, and one that will become more so, better insulated against interruptions, but not free from them, not by any means free. And if you define energy security very simply as what happens when you try to get it and you can't, I think you'll understand the political calculation puts a much higher premium on it.

Sharon Burke: So let me ask you, Kevin, I'm curious. Leslie talked about demand security, and wanted more predictable demand. Should we be careful what we wish for? Because part of what's going on now is also about the macroeconomic situation. Can you comment a little bit about what happens if the global economy starts to improve?

Kevin Book: Absolutely. The –

Sharon Burke: And like you said, sometimes we're projecting the future based on certain expectations.

Kevin Book: You want to be careful about looking to China as an endless source of demand, but on the other hand, India is coming to the rescue of the oil demand side for oil market bulls who want a tighter market, and is unlikely to relent.

One of the things about that that – I suppose over time – this changes a lot, depending on your perspective, but if you look at forecasters, and I want to be generous here, because there are some of you in the room, they come up with numbers that tend to be fairly wrong fairly consistently, but they're usually fairly well-clustered. There is an international agency I won't name that is looking out at a destination year – 2030 – where they see 77 million barrels per day of global oil demand in a carbon constrained world, essentially, a world defined by a set of economic and policy cases.

There's an integrated oil company I won't name that sees 111 million barrels of consumption in the same year. That is a very wide gulf. The truth is probably, if you ask me, more like the integrated's view of things than the international agency, because a lot of the policy premise that you're talking about isn't there.

But if you looked at that upper end number and you asked, what was the number that international agency had say 15 years ago, it was about the same number. In other words, the expectations for demand growth are usually revised to the downside. We're usually unnaturally optimistic about how much consumption growth we're going to have.

Now those in the Piketty camp think we've reached the end of growth of all kinds, in which case GDP linkages being as strong as they are, we don't have to worry about ever getting to 111. On the other hand, I would suggest that we may have an aggressive sense of how much growth we still have yet to have. We're not done.

Sharon Burke: Leslie, any comment on that?

Leslie Palti-Guzman: Well, on the LNG market side, I think there is a lot of pessimism right now about the future of the LNG industry, and whether there will be demand post-2020 and plus. I don't have all the answers, but I think the current – as I mentioned, the affordability and accessibility of LNG is much better than it used to be. If you think about it, now with the technology, with FSRU, like those floating re-gasification terminals that you can set up in 18 months or less, that has drawn to the market many small buyers that couldn't have hoped to import LNG a few years ago. So there is like a whole bunch of potential new entrants. But those are small, small markets, so you need to accumulate those small markets. ?

And then there is I think the transportation that we haven't discussed. I think the use of LNG – thank you – into transportation is – there is potentially some upside there. So the maritime use of LNG into transportation, and some projections show that you can add another size of the Japanese market by 2030, if you look at just the maritime use of LNG transportation, not just because of competitive pricing, but because of the environmental regulations that are pushing for more stringent sulfur emission, with the Maritime Organization _____ and other type of regulations that are pushing the shippers to actually look at other alternative fuels for their transportation.

Sharon Burke: Okay. I'd like to open it up to the audience for comment and question, and while people are thinking what they want to say, one observation I wanted to make is that listening to what all three of you said, one of the things that really struck me is information as a vulnerability, that it cuts both ways: there's lack of transparency about the system, and that the lack of transparency, even if it's about the masking quality of inventory, that that in itself becomes a vulnerability.

On the other hand, once you start characterizing some of the vulnerabilities, the information itself becomes a vulnerability as well. Is that a fair – that the lack of transparency in this overall system is a problem, but on the other hand, transparency could also be a problem?

Terry Boss: Well, obviously, in our market, we're pretty well deregulated. A lot of this stuff's on the internet. The good thing about our information is you need somebody like Kevin to really understand what it means. So that's the good. Sometimes too much information is hard to digest for folks, and in a lot of cases that's what we're doing, is putting too much out there.

Sharon Burke: So do we have any comments or questions from the audience? Yes?

Female: This is question of Terry, and – a specific question of Terry, and then all the panelists. The – I never thought – I've done this for a long time, looking at gas systems – that I would – and have worried a lot about electricity and natural gas interdependencies. Never thought I would be concerned about the vintage of gas wells in large storage fields. And what is happening in Aliso Canyon and the potential for problems with electricity in California this summer is of concern to me. And I think that that needs to fit into our reliability equation, and just wonder what the industry is doing on that.

And then a general question, what are your comments on energy security valuation, from your different perspectives? We're trying to put together a document to provide to the Congress, and just a general question. So thank you.

Terry Boss: Yeah. Obviously, storage is a very important part of the natural gas infrastructure. As I mentioned, we've got self-inventories out there. I do believe in the California region, it's about 60 percent of the supply on a peak day is coming out from that area. That's always an interesting market out in California. They always try something new. With the Energy Commission and the CPUC essentially taking the bet that they can get by without some blackouts this summer by keeping that field not operational, it's very interesting to see how well that plays out. I think the hydropower flexibility out there may make some difference this year, perhaps.

But there's always been a lot of work going on in the storage fields. We started standards, I think – development of standards in 2010 that would help get more consistency out there, and we have been arguing for those from the safety standards on storage fields, and Congress is about ready to pass it, and _____ is putting it in.

Obviously, DOE is involved in trying to figure out some technologies out there that we could use. But it is a little bit different infrastructure than the oil production. Generally, oil production or gas production is for a certain period of time, and then you move on to the next place, where storage wells stay there consistently, and it's a long term infrastructure.

A lot of the technology that's used out in the oil production side is, like I said, maybe set for a 40 year life or something like that. So we're looking more for integrity management type techniques out there. And so we have to adapt what is out there. But there's a lot of effort going on on that, and it's a key part of the infrastructure. And as I pointed out, as the more renewable penetration that you do have in here, the ups and downs that have to be covered by the gas is very, very important, and obviously, storage plays a big part on that.

So the results of what happened in Aliso Canyon have not been – the investigation is not complete. But we're anxiously awaiting that, to compare with what we've known before. And obviously, the perception change is rather interesting. The concern for natural gas and natural gas pipelines was public safety around the wells. If you really look at the Aliso Canyon type incident, it boils down to some public health concerns around the area, but mainly it's an environmental methane concern.

So the challenges of what you're trying to manage is changing significantly on what's important, and that was the optimization problem I was talking about. It's the cultures and what people are expecting is changing significantly. So it really requires quite a bit different thinking on those sort of …

Kevin Book: Well, I guess, first of all, to Terry's point about what people are expecting, in my last ten or so public appearances, I've asked three questions, and I'll do it now just to replicate the experiment. I think you'll get the point pretty quickly. How many of you would call yourselves climate deniers? Let the record show zero. How many would call yourselves climate skeptics? Zero. How many of you think that there's somebody in the room who would call themselves a climate denier or skeptic but didn't want to say so? Right.

So there's definitely a change in sentiment about what environmental risk you have to capture. And to your question about how do you measure risk writ large, there's so many different risk metrics you can apply, but my favorite is still the dollar discounted using a cost of capital. And so a risk adjusted return on an investment of any kind in energy security is easy to quantify, and it's a language the politicians can understand and ordinary people can use.

You can look at how much you spend per million BTU in tax expenditures. You can look at how much you spend in terms of the stream of payments over time for some sort of non-market mitigation mechanism, like the SPR. You can look at all these things in terms of the cost of the disruption or the event that produces insecurity.

Quantifying all of them, of course, is – it's an endless PhD opportunity for dissertation writers everywhere. But there are some common expectations based on an increasing set of empirical data that you can arrive at. One thing that I think is a lot better about trying to do this now than say 30 years ago, other than the speed of computers and the internet, is the direct metering of energy is starting to show up in a much bigger way, from Genscape and Bentek and other companies that aren't just – you know, they're really getting a much better sense of what the picture looks like and how you'd measure, at least here in the US, some degree of disruption.

So I think that it's – dollars is the unit to use, and that's what I would approach it with.

Sharon Burke: And you can just say something – go ahead, say something first.

Leslie Palti-Guzman: Yeah, just quickly on the global gas security, like a few things that I'm looking at the growth into the liquidity of the market, and what are the key elements that will foster that? So for sure, the ratio between the volumes that are into long term contracts versus spot is something to watch. I think in 2015, the number of importers of spot cargoes has tripled, and the number of suppliers of spot cargo has tripled. So even if the share of spot volumes has not grown drastically yet, there are many more diversity of recipient and exporter of spot cargoes.

And then the hubs, so the Asian hub is definitely something that will accelerate the growth of liquidity into the global gas market. And the fluidity, like in a way LNG needs to become a little bit more oily, like a grown up commodity, and then we'll have the same risk maybe as the oil market. But at least the LNG markets needs to become more efficient, and then there will be less risk of disruption, if buyers have the guarantee that LNG cargoes can be readily available, if there is a demand or supply shock.

Sharon Burke: The Department of Defense has struggled a bit with how to put a dollar value on energy security, but they have used a number of techniques: one is the fully burdened cost of fuel, which I think has been misunderstood quite a bit. People thought that the Pentagon was trying to price externalities, and particularly the cost of defending the Persian Gulf, but that's not what that number is. That number is looking at when you're in a combat situation and you have to move a gallon of fuel by helicopter to a remote outpost, what is the overall cost of that? You have to put force protection on it. You have to get a helicopter going out there.

And the reason they're trying to come up with that number, which is probably hard to replicate when you're talking about society-wide, is so that if you're going to make a change in your equipment or the way you operate that uses less fuel, you need to know what it's worth to you in military terms and in dollar terms, and using dollar as a proxy for military effectiveness.

They also have a measure called the key performance parameter, which, again, when they're buying a major piece of equipment that consumes fuel, they have to approximate what – for what that piece of equipment is for, what the energy burden of it is on the scenario in which you're going to use it. So if you have a large truck, for example, and it has a new alternator technology that's going to add $10,000.00 to the cost of the truck, you need to know what that's worth to you in relative terms. You can do that by calculating what its values is to you in performance terms.

So they've developed metrics like that. Where it's really gotten difficult is where it's most probably directly analogous to civil society, which is when you're talking about a military base. Let's say you're talking about a base that has cockpits that are flying unmanned systems in combat, and is running intelligence operations, and is part of defense support to civil authorities if something were to happen in the homeland. That base is mission critical (critical to the defense mission of protecting the nation's security) in three different ways, and their electricity is a critical enabler for all of those missions.

How do you put a price on that? On whatever measures they should take at the base to improve the reliability and continuity of the energy supply? And you have to put a price on it or you can't compete for the dollars, because when you sit around a budget table for a large organization like that, and someone ways, "I need money for a really important gun. I need money for this brigade to deploy," if you say, "I need money to put backup power on my base," I can tell you who's going to lose.

So, until you can put a dollar value that has a military effectiveness metric behind it, you won't win in those kinds of budgetary discussions. So it's an important debate, and hopefully, you'll come up with the answer. Please. And if you would identify yourself.

Jan Mares: Sure. I'm Jan Mares at Resources for the Future, but this comment has to do with RFF _____ individual. I want to build off of something Terry said, because I think he hinted at a security issue that you all have not yet addressed, really, and that is that we have an increasingly large number of our population who totally disbelieve the fact that we're going to need natural gas for decades to come, and they're desperately trying to destroy the ability to expand or change any of our pipeline system. And until that's addressed, and EIA through its information of our needs is trying to, but until that's addressed, we've got ourselves a real security problem.

Sharon Burke: Do you have a comment on that?

Terry Boss: Yes. I think you're very correct on that, and I would congratulate all the folks that are trying to get their stories across, and they've done a very effective communication process. And that goes all the way through our education system and everything like that.

So it's increasingly hard to do anything, and manage things on some things like that. We have achieved these goals before in the past, but we have so many competing things going on right now, I'm not sure we're going to be able to achieve these goals with the competing things. So people are being effective in not believing they need it. Unfortunately, you might end up in a crisis situation like, okay, now we don't have it. Then everybody goes into crisis mode.

So you'd like to try to avoid that. But it is a very big wave that's coming after us on these things right now.

Sharon Burke: Leslie, did you have a comment on it?

Leslie Palti-Guzman: No, just that it's one of the risks that I was addressing at the end. I think the social license to operate, this is something that we need to watch here in the US, at home, but also abroad. A ban anywhere on US shale gas can impact then production, and so this is –

Sharon Burke: I mean, at the same time, I think there are actual, real challenges in production that have to be addressed. So for example, the disposal of associated water. It is a problem – the increase in seismicity in Oklahoma and other places is related to that. You could potentially see that as a limiting factor, regardless of the social permission, the social license to operate, that that could easily be a limiting factor if you can't figure out a way to safely dispose of that water, or to treat it – which would be a win/win, if it could be affordable.

Methane, same problem. These are challenges with these systems that do have to be addressed. Go ahead, Jan.

Jan Mares: Let me just try to respond for a second –

Sharon Burke: Sure.

Jan Mares: – since I've been involved indirectly with this problem for 60 years. These are problems which have been addressed in our society during our entire life. We're putting a lot more attention on them today for a variety of societal evolutionary reasons. There is no reason that anybody has identified yet that they're not technically solvable.

Sharon Burke: No. I agree with that. I think they're technically solvable. But then the question is are they going to be economically solvable? I think you don't want to undermine the reality of those challenges, too, even if they're solvable, they still have to be in in order for this to move ahead. Kevin, go ahead.

Kevin Book: Yeah. Just since seismicity seems to be one of the throughput issues that environmentalists are currently targeting with as much effort as the industry itself, there's a reason why you use disposal wells rather than treating water. It's cost. It's the cheapest possible way to dispose, and particularly if it's close, particularly if the well was a duster or dry hole, and you just could use it again at essentially zero up front capital cost.

Changing things slowly is cheap relative to changing things in a hurry. If you have a catastrophic earthquake event believed to be linked to injection well disposal, and you shut down a significant portion of production as a response, essentially a Macondo type response, stop until you know what's going on and you can figure out what to do next, you have a system throughput problem that is not easily resolved, because most of the areas where injection well disposal is used, it has displaced all other protocols as a matter of pure economics.

So when you talk about like a security risk, that is in essence a risk. And there isn't a second plan, not yet. The second plan will take time to evolve. And doing it in a hurry would be very, very expensive.

Sharon Burke: Go ahead, David.

David Goldwyn: All right. David Goldwyn, Goldwyn Global Strategies. Some questions on gas security. Leslie, you said in the new gas order that COP 21 means that we're going to see a big increase of goal to gas, but I'm not really certain that we know how much or how fast. So I guess one question is has there been any serious analysis of the impact of these INDCs, to the extent that they are granular in nature, on the size of the increase in gas demand? And I guess a second question is if the investment isn't there because the market is over-supplied, do we have any sense of how much more greenhouse gas emissions will grow, rather than contract, because gas supply is much more expensive than people would expect it would be?

And I guess the third is do you have any suggestions for policy measures that would make that gas certainty greater, and therefore make it more affordable, for that conversion?

Leslie Palti-Guzman: So on the first question, I don't think I've seen any analysis on the commitments from each individual country to push more towards like a gas economy. I think some countries have been more vocal publicly about the use of gas, after COP 21. China, for instance, I think there is a strong political commitment to fight air pollution. And around the big cities of Shanghai, Beijing, you will see some closing of coal or heavy steel manufacturing, and that will promote gas.

India, I see it as a very promising country. If you look at the big potential consumers of natural gas, I remain optimistic for many of them. But now, in five years from now, depending on the economic situation and the cost competitiveness of gas compared to alternative fuels and economic _____, I mean, it's different pieces of the puzzles.

But I think that would be a wonderful study to do, like to go one by one through each commitment and look at what it means for the role of gas. Your second question was?

David Goldwyn: How much worse do emissions grow if –

Leslie Palti-Guzman: Oh, yeah.

David Goldwyn: – we _____ policy discussions.

Leslie Palti-Guzman: Yeah. Yeah, that's hard to tell. But yeah, that's a major risk, I guess. Yeah. I mean, what is hard is that it's really case by case, and you need to go country by country, region by region. It's still not very – you know, there is no homogeneity on the way that – there is not one password and one fits all. Each country is going to have its own energy mix and how it's going to impact energy security.

Sharon Burke: We're just about out of time, so for a last word from all of you, do you think our energy security is good, and –

[Laughter]

Sharon Burke: – if not, what's – you know, Kevin, you mentioned things that are in the red. What's flashing on the dashboard?

Kevin Book: Well, our energy security is very, very good. We have the best fuel manufacturing system for transportation fuel in the world, and we have additional feed stock in reserve if we need it. So from a – at least a fuel manufacturing and feed stock sourcing perspective, it's very good.

We also have a pretty widely dispersed and reasonably effective distribution system in place. I think – Melanie's smiling at me. There are some questions about sort of how you get it out of the reserve and into the manufacturing system and deploy it. There are certainly the – EPSA and other groups here in this building have looked at what happens if you run out of power in critical areas, and there is dependencies on other aspects of the energy system for fuel delivery. But I would rather buy gasoline here in the United States than in any other country on earth.

Sharon Burke: Where are the places you're most worried about? When you said that there's things flashing red?

Kevin Book: Most of the instabilities are actually – so it's mostly a function of artificial pricing that creates the instabilities in other places. And if you look back at the last price peak, or the one before it even more, you see countries where they simply can't afford the social obligation to subsidize consumption when prices exceed their expectations.

And so you have an artificially high level of consumption that hasn't been allowed to converge back to an equilibrium level, and all kinds of things happen. If you start with Nigeria's attempt to try to rationalize its gasoline price, which lasted, what, three days, it's very difficult thing to change, but it creates an economic vulnerability that reaches far outside the energy sector because of it.

Sharon Burke: Leslie, are we – do we have good energy security?

Leslie Palti-Guzman: Definitely I think the US has – it's one of the largest gas producers now, about to become a net gas exporter, huge competitive edge for the manufacturing and industry at home. Now the focus should be on addressing not in my planet phenomena, and put more emphasis on demand security. And I think for the US, it's like creating new demand abroad, fostering that could also push the environmental agenda globally.

Sharon Burke: Terry?

Terry Boss: Yeah. To Kevin's point, markets are wonderful if markets are designed to match expectations. And I think what we're having is the change of expectations is probably happening quicker than markets can be redesigned, and that's one of our challenges right now, is that people – it's perceived people have different expectations out there, and we don't necessarily have the dollars and cents attached to those values yet. And so we've got some broken pieces out there. We've got a wonderful system out there, but expectations maybe changing, and we need to adjust.

Sharon Burke: And so last word, I would say yes, we have good energy security, but as a defense person, I would add: the supply chain, starting from the wellhead in other people's countries to the end use, has a lot of vulnerabilities in it, and there's a lot of threat and a lot of hazard. And so our energy security is good up until the day it isn't. And I think that we need a better picture as a country of those vulnerabilities and threats and hazards to really feel energy secure.

[End of Audio]

Panel 2: U.S. Electricity Security with a 21st Century Fuel Mix and Grid

Andrew Stocking: Thanks. Welcome back to everybody here, and to those watching online. We're now going to turn to the second half of our workshop this morning about energy security in the electricity sector. The panel is entitled Electricity Security for the United States 21st Century Fuel Mix and Grid.

I'm going to turn the panel over to Mike Telson, who's the moderator. Mike is Vice President for Energy Programs at General Atomics of San Diego, California but here in their D.C. office.

Mike has a long and distinguished career working on energy issues for the Budget Committee in the U.S. House of Representatives, and then CFO for the Department of Energy here. More recently, he has worked as Senior Advisor and Director of the National Laboratory Affairs for several of the national labs. Welcome, Mike Telson, and the rest of our panel.

Mike Telson: I thought I'd motivate, give a few minutes of remarks based on my experience which, unfortunately, was a long time ago, but I think is a very useful way to sort of tell us where we came from and sort of what we might be looking at in the future. I did my Ph.D. thesis at MIT on an engineering economic topic. It was the economics of electric power generation systems, back in 1973. I finished it in 1973, and when you look at the change in the world since then, it's quite dramatic. In 1973, we had a decreasing cost industry—that is, the new kilowatt hour, the new cost of kilowatt hours was decreasing. That is not the case today.

We had a highly regulated industry, it was a rate of return industry where basically the incentive, you got paid according to your rate base. So it was a very attractive thing to do to pad the rate base, and it was basically, there was a fancy economic term for it, there was the Averch-Johnson effect—I don't know if any of you remember that, but it was basically what happens when you reward investment as opposed to performance. So, people, you had a situation where the industry not only did, in a certain sense, pay to be over capacity because your new capacity was cheaper was sort of helping drive prices down, but you also had a situation where they made money at it.

And what I did was very simply take—I'm telling you this to sort of give you some ideas of what might be somewhat relevant now. What I did was to say, "Okay, what's the incremental cost of the additional kilowatt, and what's the incremental benefit, that is, the energy you're not—the economic damage that you're not sustaining by having an extra kilowatt?"

What I found very quickly is, you can waste a lot of time getting exact numbers for losses, so what you really want to do is get some idea of what are the upper or lower bounds, and that was enough to give you a sense of if you were in the right direction, okay? So that may be another thing that might be helpful in this thing. I think it's a waste of time to get exact values in this area. Close enough is good enough, I think.

The other thing is that now we have a deregulated industry. As you know, we have the market plants, the—I'm looking for the word. What's the—say it again? Merchant plants, thank you. And that was not the case back then, and of course, we have, I think, a lot more—electricity is a lot more important to our economy than it used to be then, okay? It's like, everywhere. And things are concatenated, and if you lose power—first you have a problem that electricity has to be produced on an instantaneous basis, essentially.

You don't have the buffers that you have in gas; I forget who made that point in the previous panel. You have to do it instantaneously, and if you have a system breakdown—and that's the thing that you have to guard against, not the individual load. Going back to my thesis, what I suggested was that we should look at having controlled load shedding. So, in other words, if you have a problem, just have an intelligent way to shed load. Have pricing, peak pricing, which is not as—it's effective in the longer term, but it's not effective in an instantaneous way.

So, what you have is—again, you have a market that's very different, you have regulations, you have a market structure that used to help you. Now it doesn't. It doesn't help you in the security direction, and you have enormous costs now. If you lose a system and it's down for a day and a half, two days, three days, that's not unusual. When you have a system breakdown, you have to take the system down and then bring it back up. It's a very complicated situation.

So, with that, those three points I wanted to make at the beginning, I think we should start and hear from people who actually are working in these fields right now. David, I think we'll start with you. David is the Vice President for Exelon here in D.C. He covers all their issues, of which there are many, and a continuous set of problems. I'm a lobbyist for my industry, so I know the kind of life you live and how complicated it is.

At any rate, I'd like him to discuss some of these issues from the perspective of industry. David?

David Brown: Great. Thanks, Mike, and thanks for the opportunity to be here. I just want to provide kind of a utility perspective on many of the issues that you raise about energy security. You know, when we look at energy security on the electricity side, we look at it through a lens that includes several factors. Obviously, we want to domestic source to the extent that we can to keep security and ensure abundant and affordable supply.

We need it to be secure—secure from cyber intervention and from physical attacks. We want it to be reliable in terms of their operational characteristics, and so that includes fuel supply and the prospects for disruption there. Operational characteristics in terms of their capacity factor, how much they're available over the course of the year, their potential vulnerability to weather (whether that's sun, rain, wind, or extreme temperatures), and we look at environmental constraints, whether that is environmental regulations or water usage and our ability to use adequate water resources.

And then, of course, we want diversity, but it's important to keep in mind that, in all of the above policy has to include some from the below category as well. So a lot of times when we hear all of the above, people think of that as an opportunity to promote newer resources that are wind and solar and others.

So, Americans want reliability, that's kind of the top of the list, but they also want clean energy and affordable energy, so it's important that, as we look at this and view it through the reliability lens, that we also have to include clean and affordable in that category to meet customer expectations.

So where are we in the electric sector on domestic supply? I think we're in a fantastic spot. Obviously the shale revolution has just opened up a ton of new resources for natural gas and has dispelled a lot of concerns about domestic supply, so natural gas, coal, and uranium, if you look at North America broadly, are all in abundant supply here in North America, and we're well positioned with low cost domestic supplies of our base resources.

On the cyber and physical side, I think on the cyber side, industry is working hard to keep up with the changing threat. Obviously it's changing every day and every hour. I think we've made remarkable progress in information sharing between the government and industry. This is something that we didn't have just a few short years ago, and it's opened up a lot of new avenues of communication, and that has been invaluable to ensuring that we are able to meet this threat as it changes.

So, given the ever changing nature of that threat, I think it's safe to say that it's just a matter of when, not if, we'll have an event, so we're also planning for contingencies. We're looking at how to make sure that we limit any implications from a cyberattack and preparing for restoration and resiliency as we build out our systems.

The same is true on the physical side, whether it's weather, solar flares, or hostile acts, the industry is working every day to ensure that our assets are adequately protected, but it's simply impossible to expect every single asset in the sector to be protected from physical attack. The industry is focused on the most critical components as a result, and again, the focus is on restoration and recovery and limiting the extent and duration of any events that we see.

I would say smart grid technologies have been invaluable in helping us identify ways to work around the loss of single systems on the overall system, and it's also provided us with instant communication which, in the event of a storm, has saved us literally days sometimes in restoration efforts, because we have better information about where the outages are, and where we need to dispatch our trucks. So I know, with an event in Philadelphia a few years ago, we saved three or four days on total system recovery and eliminated literally thousands of truck rolls as a result of smart grid and the smart meter technologies.

Reliability overall, when you look at the fuel choices and the generation sources, it's obviously gonna vary by resource. With coal, it's a very practical base load source of generation, and it generally has several days of fuel on site, which is obviously helpful. It can hold up well in weather if it's properly maintained, but in extreme weather conditions, you can see the coal piles actually freeze, and so you've got to make sure that those issues were addressed, and obviously you could run up against environmental constraints.

Oh, and natural gas? Those units are highly flexible and dispatchable with quick start capabilities, which is great. Depending on the region, however, pipeline capacity can impose constraints, particularly in the severe cold. During the polar vortex, we saw a couple of dynamics at work. Number one, just capacity shortages and preference for home heating priority with natural gas, and then the market dynamic of the gas plants, if they wanted firm supply on a day ahead basis, were being asked to pay an extraordinary premium, so many of those plants simply opted out. The price was just too high. It wasn't practical to run those units. And the good thing about gas is, obviously, you've got few environmental constraints.

On the nuclear side, obviously representing Exelon, I'm a little biased in that area, but it's important to note that we've got a two year plus fuel supply on site. A lot of these plants, once they're reloaded with fuel can run literally two years nonstop, and we've seen that in many instances. It's base load generation with a capacity factor that's unparalleled, over 90 percent in recent years, and I'd note that in extreme conditions, it performs even better than that. During the polar vortex in the Northeast and PJM, we saw plants running at 95 percent capacity, and in the extremes of summer weather, similarly the Exelon fleet, I think, last summer operated at about 96 percent capacity. But those plants can see some constraints on thermal discharge during extreme cold because we're limited in terms of the water that we put back into the system.

An then on renewables, obviously, there's no fuel supply, per se, but they are intermittent resources that are dependent on the wind blowing, the sun shining, and sufficient rain to run the hydro side. Wind tends to run primarily during the shoulder seasons and at night, solar obviously is best during the day, and hydro, again, can vary by season—but very few environmental constraints other than needing to avoid birds and bats and fish for hydro.

So I think we're doing very well on improving our diversity of supply. I'll just close with one quick note on markets. You know, I think the markets are very well functioning when they are properly designed. I think right now they are designed to get us adequate supply, and they're designed to get us an affordable supply, and they do a very good job in those areas. What they are not designed to do, though, is provide clean generation that's not priced into the markets. So I think the challenge there is that, as policy makers try to incent clean generation, they need to be sensitive to the impact that the policies will have in various regions of the country. So the very same policy has very dramatically different impacts on regulated markets versus competitive markets. Thanks.

Mike Telson: Thank you. John, if you wouldn't—John Lawhorn is the System Director of Policy and Economic Studies at MISO—

John Lawhorn: MISO.

Mike Telson: - MISO, and that's an extremely important organization in our new market structure and electricity industry. John, please tell us what it looks like from your perspective.

John Lawhorn: Great, thank you, Mike. Well, it's a good segue from David to myself. Just a little bit about RTOs.

Some of you may not know what we are, or what we actually do. About 16 years ago, ________ created the RTO/ISO framework to add transparency to the markets to help price competitiveness, to eliminate pancaking, all of those items as well as to create an energy market so that there could be bids and sales at a centralized location, and also to do transmission planning. And transmission planning is the area that I work in and have worked in for several years now.

Just to give you a little bit a sense about MISO so that all of this ties together, we have about 180,000 megawatts of generation on our system. We cover 15 states in the middle part of the country, we've got about 130,000 megawatts of load, 66,000 miles of transmission, 100 kilovolts or higher. We serve a lot of members, a lot of people, and we've currently got 16,000 megawatts of wind on our system.

So that's the current situation. The next 10, 20 years looks considerably different. So we are coming out of the clean power plan evaluation, we all know that there's a stay on the clean power plan; however, that stay manifests itself. We still see many of our members pursuing clean power alternatives irrespective of the disposition of the clean power plan.

So, when you look at transmission planning, I don't know what your view of transmission planning is, but when I came to the transmission planning environment 15 years ago, it was, you have a pole and a line and you put electricity down it, and—there you go; what's the big deal?

So, as I have come to learn over the last 15 years, it's an incredibly complicated, multifaceted exercise. I've heard the Eastern Interconnection Transmission System described as the largest machine in the world. So, there are so many different components that you have to factor in so that you don't get outages in one area that cascade and affect the entire Eastern Interconnection.

With that said, let's talk a little bit about how MISO goes through the transmission planning process, because it's germane to the security of what we see coming up. So we start from an economic basis. We don't look at the pure reliability, we start with the economics. So we look at what do we need, what's the system gonna look like 20 years into the future, and we'll have bounding futures, so that we cover a breadth. As Mike indicated, you need to look at the book ends, you need to understand where you're gonna be, because whatever you plan for, you're gonna be wrong, but if you're wrong and you're in the book ends and you can adjust between what you've analyzed, you can adjust a lot faster.

So we go through and we do a 20 year resource expansion based upon the parameters that we develop with our stakeholders, and what we're seeing is, for our next set of, we call them MISO transmission expansion plans, we do one every year—what we're seeing is, from that 180,000 megawatts of generation on our system, the trends are coal retirement, then gas retirement, significant renewable investment, energy efficiency, demand response, and distributed generation. Add in the flexibility of storage, which we are right at the forefront of, and those are the types of parameters that we're looking at moving forward.

So, for the current study process that we're on, we are looking at potentially 50,000 megawatts of—we're looking at 33,000 megawatts of coal retirements in the next 20 years. That trend is growing as we look out in the future. We're looking at 50,000 megawatts of renewables—mainly wind and solar. Where we are, it's mainly wind, but as the solar technologies increase, that distribution will start to change.

We're looking at energy efficiency on the order of 10 to 20,000 megawatts. So what we're seeing for resources are a retirement of our base load facilities, those facilities that operate around the clock, day in and day out, to the replacement of those facilities with intermittent resources. You know, wind, for example—in order to get the same level of security from a reliability standpoint, our figures indicate you need 7 megawatts of wind to equal 1 megawatt of a base load unit.

So, we're retiring 33,000 megawatts of base load. You gotta replace that. If you replaced it one for one, you'd need over 210,000 megawatts of wind—because wind is intermittent, and you need a broader geography. The broader your footprint is, the better off you are, but as you go down to smaller localized regions, the need for diversity of resources becomes even more important.

So with that resource mix that we're looking at, we need to develop a transmission system that meets that 20 year out time horizon, and one of our challenges, and a challenge of the industry is that you can install a wind facility in 18 months, but it's gonna take you 8 to 12 years to put in the transmission system. You plan it, you go through all the regulatory issues at the state levels—we're at 15 states—many of these facilities are cross state, so you have to have each state give the approval for it.

So you're looking at near term generation being added that's of intermittent value and a long term transmission build out requirement. And why is that important? Well, it brings us to the final piece of the security issue is that, historically, a lot of the wind and—well, I'm gonna stick with wind; I'm not a solar expert. But most of the wind is, the high value wind sites have been located in sparsely populated areas.

So you've got a great deal of wind potential in the middle part of the country that isn't anywhere near transmission. So, developing the transmission that efficiently and cost effectively meets the objectives of aggregating wind and solar and delivering them to the load centers is an incredibly important process of the forward looking transmission development. And that's where we are currently looking—establishing centralized wind zones. Instead of where are the pockets, kind of the "build it and they will come" from *Field of Dreams* type of analogy. But if we tell our stakeholders from working with them that we see 20 or 30 different high value wind sites and that we'll build transmission to link those sites up, generally, the developers will head to those transmission sites, to those wind sites.

So that's what we are currently working on, and we are at the forefront of developing a major transmission build out. It's gonna take four years to get us there. We had one of these in 2011, which was built to meet the state goals and mandates for renewable energy. The next build out in 2019 is when we expect it to go to our board of directors. It is intended to meet the emerging lean energy push, the de-carbonization of the marketplace. So with that—

Mike Telson: That's very good, thank you. Gary, would you fill us in on—Gary is the, ABB is Asia Brown Boveri?

Gary Rackliffe: Asea Brown Boveri.

Mike Telson: Asea Brown Boveri—you never use that any more, right?

Gary Rackliffe: No, we use ABB.

Mike Telson: See, I'm old enough to remember. *[Laughter]* So he's the ABB Vice President for Smart Grids in North America. I think this is a very interesting area for us to consider now, and Gary, please tell us what it looks like from your perspective.

Gary Rackliffe: Well, we're certainly excited about some of the changes that we see in the industry and also how we can help address the security of the grid and security of supply.

I do want to start out by saying to John, we can build that transmission line for you.

John Lawhorn: *[Laughter]*

Gary Rackliffe: If you want an HVDC link between North Dakota and Chicago, we can put that in. *[Laughter]*

ABB is a power and automation company. We're the largest global supplier of infrastructure to electric utilities. We are headquartered in Zurich, but we have operations here in North America—actually, the Americas, our headquarters for that are in North Carolina. We employ about 20,000 people here in the U.S. and people up in Canada as well, so we have a very, very strong footprint here in North America.

So in terms of what we were asked to address in our comments — ~~were~~ some of the factors that do influence the grid and security of the grid — I wanted to highlight some of the things that we see relevant in terms of trends and where we're focused.

Since we're in the same industry, I'll overlap a little bit and touch on some of the same things that David and John mentioned, but I wanted to start with weather, because we've seen a significant change in weather related outages, particularly in the Northeast. I think the signal for that change was Superstorm Sandy and it also caused a significant change in terms of how utilities in that region are operating. Part of it is to harden the grid, which means it's resistant to impact of storms, and we've done things such as elevate substations using gas insulated switchgear and technology which enables more compact and flexible substations.

We've also done things to implement microgrids to improve resiliency if you do have localized generation to serve critical loads. And then overall, we're automating the grid so that we can isolate faults when they do occur in the system and then restore customers who are in unfaulted sections of the grid by supplying power from adjacent feeders and doing that with an automated process.

We’re including situational awareness — we’re leveraging smart meters where they indicate outages, and we’re using analytics for three applications. We use analytics to predict the impact of storms and what might be the expected damage. That allows utilities to better stage their crews and also to better manage their supply chain.

When the storm hits, we use analytics to determine what’s happened—where is the damage? Where do I need to send the crews? How to I mobilize efficiently and get customers restored as quickly as possible? Key to that is the situational awareness—telling the customers who’s out, where the outages are, when they’re going get their power back. And then post event, it’s analyzing the performance of the storm response—can we do better, are there systemic problems that we can use to harden the system? You know, social media is now playing a factor. We also see, some utilities using drones to get information. So we’re seeing some changes in that space.

I guess “weather-related” is also solar flares and geomagnetic storms. This has actually been a concern in the industry for a number of years. There are technologies that can solve this concern. One of the major problems is that geomagnetic-induced currents can cause saturation of transformers that are grounded and overheat the units. Instead of having what’s known as a solid metallic ground for the transformers which are grounded, we actually can change that and put in a dual ground, one which is solid, but if you detect geomagnetic induced currents, you can interrupt that solid ground and then re-route the ground through a resistor and a low impedance capacitor which effectively blocks the geomagnetic currents.

That also works for EMP, or at least the E3 component of EMP. With regard to the E1 component, I’m not sure we know exactly what the effects would be from that electromagnetic pulse. Certainly it’s a high frequency or high intensity pulse, and there are standards in place that we can meet with shielding. We’re also looking at fiber optic cables inside substations, which would be immune to EMP, and shielding the control devices as well, but there’s more work that needs to be done there.

Physical security, we’ve talked a little bit about that. The Metcalf incident back in 2013, certainly highlighted that our cameras in substations may need to look out, as well as within the substation. But we’re working to harden power transformers and shorten the lead times; Transformers were the key assets that were targeted in that particular attack. We’re replacing porcelain bushings with composite bushings, which don’t shatter when they’re struck by a bullet. We’re also applying armor coatings to the external part of the tank to protect the core and coil so it can withstand a.50 caliber rifle shot and we can at least protect the tank. And we can protect and shield the cooling system which is another critical component. Utilities are also looking at building walls around the units to provide physical protection.

But we're looking at, how do you protect the core and coil? How do you protect the auxiliaries? How do you make sure that if cooling is damaged, you sense that immediately, shut the transformer down—because cooling systems are fairly easy to repair? Replacing a transformer is a very long lead time item.

We have participated in the rapid recovery transformer initiative, which was supported by Homeland Security, the Electric Power Research Institute, ABB, and also we worked with the utility CenterPoint. This initiative showed that we can quickly replace a transformer and move transformers into a substation in a very short period of time, assuming that there's available spares with the right technology.

Today, in the industry, about 3 percent of the power transformers are what are called large power transformers, but they carry about 60 to 70 percent of the load. And so if we can identify the common types and then build certain types of units that meet those requirements that are ready for quick ship, we can increase the resiliency of our grid and the potential threat to large power transformers.

There's a lot of things we can do. We can use insulation that's more compact—a little more expensive but more compact so they're easier to ship, we can build platforms into the base of the transformer to minimize the need for a pad. We build these for shipping with trucks, although you can use rail, but it gives you more flexibility. They're all single phase units which are smaller and easier to ship, not three phase units, so you do need to move three transformers to get a bank. All of these things were part of the demonstration project that we conducted.

Another issue that we see is aging infrastructure. We build power transformers, the largest producer of power transformers in the world, and for those of you who wonder—yes, we do build them in the United States, and we also have a large factory just over the border in Canada. Power transformers were originally designed for maybe 30, 40 years. There is a significant number of the fleet that's installed today that's 60 years or older—big build out of our transmission grid in the '60s and '70s, and most of those units are still in place.

There's also an issue, too, of whether the workforce working on these transformers to make sure they perform are older than the transformers. The aging workforce is an issue that we need to address. But we're applying analytics to help track the performance and predict how these units are going to perform in the field so that we can service them if need be and replace them if they've reached their end of life.

Another topic that we introduced during our preliminary discussions was electricification of transportation. We're in the fast DC charging business, that's part of our portfolio. So we got real excited when one car company sold 325,000 cars in one week and they haven't even built the car yet. So hopefully that'll spur some growth or continue to fuel the growth for electric vehicles—the Tesla Model 3 is certainly at a lower price point.

Today, I think that electric vehicle charging infrastructure for utilities is still a demand response application. It can be controlled, you can turn it on and off, you can incent consumers to charge during off-peak periods, and you also can change the charging rate. So you really do have a demand response tool.

Vehicle to grid—I'm not a car manufacturer, but I don't think the batteries in the vehicles today were designed for a duty cycle that includes charging or supplying power to the grid, so I think that's a little bit away. ABB is demonstrating another EV technology in Europe—we have an electric bus in Geneva that runs around the city with no wires. The buses pull under an awning at each bus stop and get a flash charge for the on-board batteries so that they can make it to the next bus stop. It's part of our Smart Cities initiatives.

We're also doing things with ships and electrification of harbors as part of our Smart Cities initiatives. We're providing shore to ship electricity while the ships are in the harbor to minimize diesel generation running on the ships to provide their on-board power —so again, part of our Smart Cities and sustainability initiatives.

And then the last item I wanted to talk about is Smart Grid. I mentioned automated switching is part of storm response and outage management—that's a key part of improving grid reliability. We're also pushing efficiency of delivery, reducing distribution losses and managing feeder voltages through volt/VAr control and volt/VAr optimization. Managing feeder voltages has become more complex. For example, now that we have smart inverters, the power electronics are another controllable item that we can to use to manage the impact of distributed energy resources on distribution feeders.

I mentioned analytics for managing health of assets, also for improving grid performance. We can also analyze the meter data from AMI (Advanced Metering Infrastructure) to evaluate customer preferences and demand response programs. Also very important, is how do we forecast the variable and intermittent renewable resources such as solar PV and wind to determine how they're going to impact the generation mix. Forecasting these resources is a real challenge, and we're using analytics to make some headway against that.

Which brings me to integration of distributed energy resources. There's really three things that we look at. One is, how do we manage the impact locally, how do we manage the voltage on the distribution feeder when you have these resources? How do we protect, particularly if there's a reverse power flow condition? That's a challenge that we have as an industry. Second is, can we leverage these resources as an integrated resource at the distribution level to offset capacity investment? California has required the utilities to do that. They had to submit their plans last summer. And then third—this is going to be particularly important to John—how do we coordinate distributed energy resources with centralized generation? Because they can have a profound effect on centralized generation, and I'm not just talking about the variability or the intermittency, which is an issue, but it can dramatically change what is the the new base load, the ramping requirements, and the capacity utilization of centralized generationI think that's something that's real key for our industry now is, how do we address that coordination?

But we're excited about renewables. We don't actually do wind generators themselves, but we do the controls inside, the power conversion systems, switchgear, transformers, and grid integration. Power electronics are an element of wind generator power conversion systems. Power electronics are also an element of solar PV inverters, we supply those as well. It does contribute to a concern that these gentlemen here have regarding the inertia that's built into the grid, because power electronics switch off immediately whenever there's a disruption. They don't have any inertia behind them. So as you start to retire coal, having grid inertia becomes more of a concern.

We do have a solution. We can provide static VAr compensators which can partially offset the lack of grid inertia, and provide voltage support to the grid. Storage is a silver bullet, because it decouples supply from demand, but until we see some major breakthroughs in battery chemistries and manufacturing efficiencies, I think the advances are going to be somewhat incremental in terms of battery energy storage. There are other storage technologies, for example, we use flywheels as well.

That said, lithium ion batteries were about $1,000.00 a kilowatt in 2010, and prices are now going to be around $200.00 a kilowatt in 2017 time frame. I think what's also interesting, if you just look at the statistics on solar power, the learning curve for solar PV is every time you double capacity, you lower the cost by approximately 24 percent, and there's been seven doublings in the last 15 years.

Wind is not quite so extreme—it drops about 19 percent in price every time you double its capacity, and in the last 15 years, we've seen about four doublings of wind generation capacity. But globally, and also in North America, we're moving to renewables. Wind and solar are the key components of the renewable portfolio that we see being deployed.

And with that, I think I used more than my time, so I'll turn it over back to Mike.

Mike Telson: Sure. Thanks. Curtis St. Michel, he's with the Idaho National Laboratory. Please tell us what—I know you have a very broad purview over there, so please tell us your view of these developments.

Curtis St. Michel: Okay. I'm going to over kind of a specific aspect of energy security, more from the possible impact of cyber security as we deploy out these new technologies that enable all of these changes, whether we're bringing in renewables, diversification—all of this is gonna require fundamental changes in the level of communication, the sensors that are in the field, level of automation—all of these, this is fundamentally different, so I'm first and foremost a control engineer. I've been doing this in nuclear and utilities for about 25 years, and the capabilities, the technology capabilities and the analytic capabilities that are available today were basically science function when I started.

But, with that, there comes—it's kind of a double edged sword. I've also had the opportunity in the last 15 years to really focus on what is the cyber security impact as we move to much more automated systems. Utility systems move slow, but we are rapidly starting to adopt as the existing build outs start to age out, we're replacing these systems and they're much, much different systems. At the same time, the cyber threat, especially in the last 15 years, has changed dramatically. It has evolved and diversified, and the cyber threat today is much, much more sophisticated and worldwide than it's ever been.

And, at the same time, the industry has done, and the regulatory agencies have done quite a bit to evolve, also. When I started 15 years ago going to conferences on this, when you talked about energy security, there was little or no conversation around cyber security or physical security. Today, there's big sections of every single conference that really talk about those vulnerabilities.

My concerns, as we move forward to this age where we're gonna become increasingly reliant on these technologies to enable a diversified electric grid is that, at this point, we're still very much in the tit for tat fighting in the technology realm. For everything that we've done—and the electric industry is much more cyber aware and much more prepared than they've ever been. However, as we've seen from the news and the events that have happened, it is very difficult if not impossible if you have a dedicated threat actor who's targeting, they will get into a system. And this is—we've seen this play out again and again and again.

And, as he mentioned earlier, my colleague mentioned earlier, it's pretty much inevitable that somebody will get in, and we need to understand what that impact is. Part of that's going to be understanding the economic impact and how do we recover, but I think it's also important to think about it from an engineering perspective. If we're gonna fight this battle always on the technology realm and just say, "Well, we gotta keep 'em out" and that's the only answer and we don't really investigate what are the possible impacts, it's going to be very difficult to make the long term investments or very specific investments to those items which really would change the reliability of the grid, not from a failure mode, but from a mal-operation of the very devices that we're relying on to control and protect that grid.

So, in my view, one of the biggest challenges going forward is to kinda change that engineering and risk management thought process to erase what I call the trust bias that we have. Right now these systems are basically designed where it's a bastion defense where we keep 'em out, and inside of that bastion, we focus on failure modes and reliability and functionality of the systems. And that's gonna be very important, and we need to do that moving forward.

This isn't gonna—I'm not ever going to recommend that we don't automate or bring in these capabilities. However, I think we do need to consider, from a trust basis, what are the critical functions in the system? Not just critical components, but critical functions, and how do we rely on these digital devices? And if we erase that trust bias of, if you're inside, I trust everything that's either done by a device or what anyone who interacts with that device, then we can start to think about some of those critical functions in a different way and put some engineering controls in place. I think that's gonna be really critical, moving forward.

That's all I have to say.

Mike Telson: That's very good and scary, appropriately. *[Laughter]* I'll just start with a couple of questions of my own. David, you said that the system was not well designed for clean energy. Is it well designed—the central system, regulatory system—is it well designed for security issues? I'm referring in particular to your early retirement of some nuclear power plants in Illinois.

David Brown: Oh, sure. Well—

Mike Telson: Not an easy question, by the way. *[Laughter]*

David Brown: It's not an easy question, and I think that it, at the end of the day, does go back to putting a premium on base load generation and putting a premium on clean generation, and I think that we are, unfortunately, in a position where, over the last several years, we have lost literally hundreds of millions of dollars at just three units. And we have kept them operating under the hope that, in the out years, we'd get to a point where carbon had a price on it, either implicitly or explicitly, and that natural gas would rebound and that we'd be able to at least break even there, if not make some money.

At this point, though, there's very little prospect that we see of gas shooting back up any time soon.

Mike Telson: Right.

David Brown: And even with Clean Power Plan, the way it was structured, it does very little to help the existing nuclear fleet. So, look, I think it's one of the challenges in competitive markets is recognizing the longer term value and longer term implications of that. If you look at the carbon value that the nuclear fleet brings to the country on an annual basis if you use EPA's social cost of carbon as a proxy, which some people dismiss out of hand, but others think is way too low, it's about $33.5 billion annually.

So, if you look at the value of extending the existing licenses of those units, 100 or so units, for 20 years, the value from a carbon perspective of that 20 year license extension for the fleet gets close to

$1,000,000,000.00 when you look at the indexes that EPA includes in there. So it's—or $1,000,000,000,000.00, I should say. So it's an enormous amount of money. It's an enormous value, but there's no mechanism right now to recognize that.

Mike Telson: Right. And of course you lose the spare capacity that you have now with those units. Let me ask you, Curtis, about—it seems to me that as we've decentralized the system and deregulated it, there's an immense number of new entry points to the grid that have grown over the last 20, 30 years where you have the microgrids that you're talking about and just, you know, different people can sort of plug in, so to speak.

What does that do to the cyber issue, and how do you protect against that?

Curtis St. Michel: So, the big concern in cyber is always your access footprint. I mean, that's one of the main considerations is your access footprint. So, as the endpoints push out into uncontrolled areas and you have better and better communications to those endpoints, it increases the number of points with which somebody can access the system.

There's mitigations for that. A lot of people will say that encryption is an answer for security in many cases—and it is, from the aspect of somebody trying to jump into a communication path between two points, but if I own the endpoint, if I can physically access the endpoint, I can then use that, and actually encryption becomes a problem because you're now hiding malicious activity on that link.

Mike Telson: Right.

Curtis St. Michel: So, in the end, as was said in the last session, you can't defend everything. It's impossible to defend everything, especially when you're going to push out this digital boundary. So the important piece is to understand what are the functions, the important functions in the system, and make sure that you do all the hygiene and all the things we need to do from a regulatory perspective, but also engineer those systems assuming that someone's going to get in and have, we call them disruption zones or things in the system that will allow—even if somebody's in, from a business perspective, I'm able to rebuild and start again, but for some critical functions, we want to be able to maintain those, so that's a really important piece of understanding.

Mike Telson: Is there any way to use—I've heard of people talking about analogue controls being put in as bridges between digital controls just to see if that would help put some air space, if you will. Does that make any sense, from your point of view?

Curtis St. Michel: I think it's a very, it would be an application specific, it's very specific to a particular application. I don't think there's a general panacea anywhere here, because, unlike in an IT system, when one of those systems is compromised, the first order of fact of somebody going in and compromising it—they're there to get the information or destroy the information. Owning that technology gets you the effect. With operational technology or control systems, owning that technology is only a piece of it.

You also have to understand how to manipulate the system, how it's used in operation. Those are all big hurdles to overcome for any kind of adversary, and because of that, they have to learn a lot about the system. This allows us to design—these systems become very defendable if we assume somebody's in there and has to move around in them, and has to get to certain places and collect certain information. So there is ways to protect these systems and protect critical functions.

Mike Telson: John, I'm wondering, the 2003 blackout, Northeast/Midwest blackout—could you explain to us exactly how that happened and what the effects of it were? If you're aware of it.

John Lawhorn: I'm aware of it, it was in August of 2003. The industry has changed dramatically since that point in time. The ability to dispatch those facilities and get them to follow dispatch decisions has changed dramatically the units that were driving the issue. And you know, in the planning process, we planned for an N-1 contingency, or N-2. Meaning, what happens if sometimes goes out and then something else goes out—2003 was somewhere around N-8 or something. I mean, it was very far down the process. And a lot of the generators and systems that were involved, they were in RTOs, but they weren't in what we call a day two market, so the actual dispatch and coordination of the facilities was not under control of the RTO.

Mike Telson: I see.

John Lawhorn: So it's a different world since then, and there's more security put in place to communicate that.

Mike Telson: How many days were some people out?

John Lawhorn: I don't know. It was localized to, I mean—I remember the Detroit and Cleveland areas were more impacted, but I don't have an itch—

Mike Telson: But it was not a few hours, it was a couple days, that kinda thing?

John Lawhorn: Some load pockets were out for longer than others, but I don't have the specifics on it.

Mike Telson: That's right, yeah. Yeah, that's always something that's impressed me is that these things can happen in the electric systems just because of their nature, and it's not something people just think you just shut it off and put it back on kind of thing where you have enough power. And I think that's something that has to be very much factored into what we do about it, you know?

I'd like to turn it to the audience right now for a few questions. Any questions? Jan?

Jan Meyers: I'm Jan Meyers of Resources for the Future. This is a question for Mr. Lawhorn based really on the observations of Mr. Brown about the importance of security and reliability of our electric system and the important role that nuclear plays, not just in the pure power, but in the reliability and a whole bunch of other things.

To what extent do the RTOs have either the legal ability or think it's their responsibility to set in motion ways to keep this nuclear side operating for our country?

John Lawhorn: That's an RTO specific question—

Jan Meyers: Well, it's a general question.

John Lawhorn: - and I'll talk about both of them. So, in the Northeast, you talk about deregulated markets, so the PJM, the New England, the New York environments are all de-regulated. In other words, the generators need to recover their costs through the energy price in the market. In the Midwest and westward, for the most part, we are not deregulated, we're still under the traditional regulatory paradigm of, the regulators put facilities in rate base, and the generators would recover their capital investment via that mechanism.

So, Exelon is primarily in the PJM system where the capital costs for their facilities have to be obtained through market mechanisms. There's the capacity market and the energy market. In the MISO footprint, the majority of the generators are being funded through rate base, as far as their capital costs. So, the one difference is that Illinois is a deregulated market, and their facilities are in Illinois. So, it's—I understand their issue, you know? They're trying to recover, keep their capital investment as well as their energy through various market mechanisms. The capacity market in PJM is different than the capacity market in MISO, because most of our facilities are regulated. So there's a very different price or value depending on where that resource is located. If it's in Illinois, it's around $150.00 per megawatt hour, I believe, or per megawatt, whatever the—and if it's in the rest of the footprint, it can be $3.00.

So there's a wide disparity on how those costs are recovered, so it's cost recovery mechanism, cost allocation issues. Within MISO, we have—if a facility is going to retire, they have to provide us notice six months in advance so that we can determine what the impact of that facility is on the transmission system, and if the impact is significant enough, we will propose solutions, either on the generator side or on the transmission side, to mitigate that impact.

Mike Telson: Okay. Alright, any—go ahead.

Cyril Draffin: Cyril Draffin with MIT for Gary. Could you talk about how ABB builds cyber security into your power electronics, and also your recommendations over the next decade, how the cyber security strength of the grid should be enhanced.

Gary Rackliffe: Sure. I'm not going to profess to be a cyber security expert; we'll let Curtis cover that today, but there are two parts to this. One, you asked specifically about the power electronics, but we also provide systems, that are used to operate the grid. We have the software, for example, in New York, we also have software in ERCOT here in the U.S. and we have other installations around the world.

This is based in part on testing that was performed at Idaho National Labs—the software is very much protected in a hardened core, both physically as well as from a cyber security point of view. The weak point that occurs in a system, which is what Curtis identified, is the sensors, the controllers, the devices that are outside that secured perimeter that are deployed within the grid. So we do meet all of the standards for cyber security for our controllers, our RTUs, our relays, and all those other devices, but even doing that, there still are vulnerabilities that are at the fringes.

On the power electronics—again, it's the controls and the software for systems based on power electronics that could be vulnerable from a cyber security point of view. We comply with all of the applicable standards that the industry has, whether it's encryption or architecture or configuration to make sure that those systems are hardened.

As an example, we sell HVDC lines and cables, and of course we have a controller at each end. Those are largely dependent upon power electronics, whether it's either thyristors or voltage source converters. And there, we try to eliminate the perimeter components outside the system that allow penetration into the controls. And that would be the same thing for static VAR compensators which also have the power electronics. At the other end of the extreme, we provide micro inverters, but the solar inverters that are up on top of somebody's house are not likely a cyber security threat. We treat substation automation, in a similar manner as we treat our SCADA/EMS systems.

Mike Telson: Please.

Fred Hoover: Sure—Fred Hoover from the National Association of State Energy Officials. An earlier panel discussed potential threats coming either from vandals, criminals, or nation states. Now, you can envision a scenario where, if the perpetrator of a cyber event was a nation state, one of the prime targets might be the electric grid, if you really wanted to foul up the response by the country. Is there a federal responsibility to help protect the grid from those levels of threats, which could be of a sophistication that was mentioned earlier to actually cause significant damage to the electric grid?

Gary Rackliffe: I believe, as was mentioned earlier, Admiral Rogers from NSA basically stated that this is a national responsibility, that there is capability out there to disrupt our critical energy systems, and that it is one of the functions of various elements of the government to respond to that. It is—they're moving forward on different efforts and we'll see. *[Laughter]* I don't think there's a single answer at this point, but they are moving forward working with industry.

I think we mentioned there's much better data sharing between the utilities and the government at this point, and there's lots of response capabilities. It does need to evolve as we go. It's much better than it was before. I think that the role of how does the U.S. government help the utilities will be evolving.

Mike Telson: Okay. Please—go ahead.

Suedeen Kelly: Hi, my name is Suedeen Kelly, I'm a lawyer with Akin Gump, but I'm here on behalf of Save Our Power, which is a public awareness campaign of Save Our Grid, which is a nonprofit organization whose mission is to work to ensure that both government and the industry and other stakeholders take the steps necessary to improve the security and resiliency of the grid.

My question, I think, is really a follow on to the last question, and that is—as you look at the funding that's going to be needed over the next series of years to accomplish this objective, have you thought about who should do it? Historically, the owners of the asset make the investment. In today's market, as some of you have alluded to, that can be a challenge, particularly if the asset is in the competitive market.

So, should we retain that business model? Should we look at it more communally? For example, in those parts of the country where the transmission assets are operated like MISO with an independent system operator, should it be a funding obligation of the community of owners? Should the federal government take on the responsibility of funding it in whole or in part?

So, I'd appreciate your thoughts.

Mike Telson: *[Laughter]* Anybody?

Male: That's a great question. You know, there are communal funding, there are all sorts of cost allocation provisions depending on the type of transmission being built. So, some of it is socialized, depending on the voltage, because it has direct benefits to essentially the entire footprint.

The areas that could potentially benefit from additional federal funding would be the hardening of the transmission structures. I mean, we've got hundreds of thousands of miles of transmission lines that are out in the middle of nowhere, and they're carrying a great deal of power. I think they're very vulnerable. As we look forward, we have evaluated the undergrounding of long transmission lines. It's quite expensive, but that is something that, going forward, I think should be looked at. Because, as the undergrounding would take place, the costs would come down, and having a reduced vulnerability to those facilities above ground, I think, would have a great deal of value.

Mike Telson: Very good. Anybody else? Is that okay? Do you want more comment?

Suedeen Kelly: I'd love more comment. That was great, though.

Mike Telson: Okay. Anybody else want to say something?

Male: It is a large challenge to look at some of these things. I've mentioned the whole fact that studying that trust model on the engineering basis, it's very, very hard to do that from a—if you have to recover the cost. It probably is a government function working closely with industry.

It's a tough question because the U.S. government can bring capabilities to bear, but most of the knowledge necessary to actually effectively deploy those is within the industry itself. The government doesn't have either the knowledge nor all the specifics to come up with the right solutions. So the right kind of partnerships that'll allow research to go forward and how do we secure those tough challenges are gonna be needed. And I don't think we have a clear path forward. I think there's lots of fits and starts of examples, but I'm hoping that, as we move forward, we can look at that.

Mike Telson: I wasn't gonna say anything, but basically, it's my—well, what I've heard today has been very encouraging in many ways about the things that you're doing, each and every one of you.

But my suspicion is that the damages to the country, the potential damages to the country, if there were some dedicated terrorist or some crazy person—you know, which, these are things which, 50 years ago, we hardly thought about. We did think about it a little bit, but now we think it's much more reasonable that those damages are so much greater than what would be in the interest of any single company to protect against that I think there's a great role for—I hate to say federal, but for something that is able to sort of take these interests into account in a bigger way.

What that structure would be, I don't know, and how it would be financed, I don't know, but that's just my gut feeling. Do you guys agree with that?

David Brown: Yeah, I think that's right. I mean, I think that—look, there are obviously challenges in all three aspects of electric delivery. You know, transmission, there are some mechanisms to socialize the costs; distribution, obviously, is still regulated at each of the states, and so there's a cost recovery mechanism there; generation is kind of a 50/50 proposition at this point.

I think the real question and the discussion that's taking place right now with policymakers is, how far should we go to protect assets against nation state actors? I mean, there are some who are advocating that we protect the system and try to gold plate it against electromagnetic pulse threats, which I think, from an industry perspective, is just simply impractical. I think there have been some estimates that it might cost as much as $2,000,000,000,000.00 to try to do that. So I don't know who's gonna sign off on that check, and so I think, as the discussion continues and as we build out our capabilities at the labs and elsewhere to kind of figure out exactly what the nature of the threat is and focus on kind of isolating the impact of any event like that, and then recovering the system as quickly as possible, that's where we have some real opportunities.

And I'd just say, I mean, we've talked about this government information sharing, data sharing—the department has really led the way in terms of critical infrastructure. The Electric Sector Coordinating Committee that the Secretary helps drive has been really just invaluable in getting the industry very well positioned, and we've made great strides in the last few years.

Mike Telson: Okay.

Suedeen Kelly: Thank you.

Mike Telson: Sharon?

Sharon Burke: Yeah—Sharon Burke, New America. I had a question about energy security valuation. I'm sure, with your analytics, and you have a lot of sophisticated tools, that you have a very good idea of what reliability is worth to your businesses, and I'm wondering two things about that. First, is it generalizable out to other energy security challenges, other aspects of that vast system; and also, when you do make those calculations, do you take account of upstream risk? Do you take account of terrorism threats and EMPs, all that stuff—do you price that into your calculations about what reliability is worth?

David Brown: Yeah, just a quick rundown on that, I guess. I think we look at two parts of that on the graph, right, is number one impact, but number two, likelihood. So, a very impactful event with a very low likelihood we won't give as much credit to.

So—but yeah, we look at reliability all the time. And I think one of the things that we hear from some of our customers is that reliability is more important to some than others, this whole idea of power quality and ensuring a steady stream of electricity into a high tech facility, for example. There's a premium there. So, how we go about ensuring that will work with individual customers. Some of those customers want additional resiliency built into the system or additional safeguards, but yeah, as we look at what we're going to build next, we price a lot of things into that, but obviously reliability is kind of at the top of that list.

Gary Rackliffe: I think it's an interesting question. When we look at reliability, there's the reliability constraints of the grid and what investments are needed to make sure that the grid doesn't become unstable. We don't want to have a major event, so grid operators analyze the N-1 and N-2 grid contingencies and make sure there's sufficient capacity and infrastructure in the grid to be able to ride through disturbances.

The challenge, though, I think—and I don't want to put any words in David's mouth, but I think for our customers, the challenge is how to qualify or quantify the reliability and its impact. So if there is an outage, there are direct costs associated with restoring the service to customers. If the equipment gets damaged, there's a direct cost associated with that. But utility customers do value reliability very, very differently and have very different opinions about impacts of reliability. As an example, data centers will go to the extreme of putting not one redundant supply, but two redundant supplies in place, because reliability is so critical to them.

A momentary interruption could be very disruptive for a process dependent facility—or the impact of a sustained outage will increase depending upon its duration. There are calculation devices to try and put a monetary value on interruptions, but they're very, very much an estimate. For a cyber related events, we see NERC CIP defining the basic criteria as to what utilities need to do. As a vendor, I won't say we're not impacted by NERC CIP requirements because our customers are the ones who have to go through the audits, but if they don't have the equipment and the tools and the measures in place from the vendors, obviously they're not going to be able to meet the NERC requirements.

We see the cooperation between the labs, the government, and the utilities, and the sharing of information on the type of threats that are now facing the utilities. The threats impact us, and they also impact our suppliers, because we embed products, software, nd other components. There's a supply chain impact, and it starts with the utilities and it works back through the vendors. But I do think we have strong partnership in the industry today because we all recognize the threats. No vendor wants to have their system in the news as having a problem. So we want to make sure that our software systems are also protected and help our customers meet the requirements that they need to meet.

Getting back to who pays for that, though, that's—you know, right now, it's the people who own the assets who are paying for the compliance with the cyber security measures.

Mike Telson: But they may have no way to recover those costs.

Gary Rackliffe: Well, the costs get recovered one way or the other—either the rate payers pay them or the shareholders pay them, somebody must—and if the government steps in, the taxpayers pay for that.

Mike Telson: Exactly.

Gary Rackliffe: It's not free.

Mike Telson: No free lunch, absolutely. Go ahead.

David Brown: Yeah, I wanna find out how much the lunch costs.

Mike Telson: *[Laughter]*

David Brown: So, of course, burying lines, that's, like, super expensive, but Gary, some of the—you were talking about a lot of the newer technologies. This is incremental kind of technological improvements, software and hardware. So can you give a sense, and maybe for John, too, or others, of what this means, the additional layers of protection mean for rate payers? Assuming that all these costs were passed on to rate payers, what kind of changes are we talking about?

Mike Telson: You mean, is it 5 percent, 10 percent, that kind of thing?

David Brown: Yeah, cents per kilowatt hour, you know?

Mike Telson: Yeah. I like percentages better, but that's okay. *[Laughter]*

Gary Rackliffe: It's going to be difficult for me to say in cents per kilowatt hour what the impact is, but let me just give you some examples of what technology can do. In Texas, with the large amount of wind in the western part of the state, the transmission grid was constrained in Texas. So there was a significant build out to accommodate the wind generation in the West and be able to move that to the East.

As part of that build out, there was also an effort to leverage the existing transmission capacity and get more capability out of it. Now, without getting too detailed in terms of what the limits are on capacity for a transmission line, there's basically three factors that come into play. One is, there's a thermal limit. If you put too much power down the line, it heats up, it sags, and that's a problem. The second is, there's also a limitation based on the voltage at one end of the line versus the other end of the line. That's a physical limitation as to how much power you can get from one end to the other based on what the voltages are at either end.

But what really drives the transmission capacity limitations is the transient stability limit, which means, if you lose that line, is your system still going to be stable? So you can continue to load up the line to the point where, the loss of line causes customer and part of your system's goes down. That's the limit that really drives how much power we can move down a transmission line.

A static VAR compensator provides reactive power using inductors, capacitors, et cetera, and injects that into the grid to support the voltage which allows the grid to ride through disturbances. The SVC relaxes that transient stability limit, so you get more transmission line capacity than you would've otherwise.

Series capacitors are another type of what they call FACTS—flexible AC transmission systems—which offset the transmission line inductance. It offsets this inductance and makes the line more efficient, which means you can now move more power through it.

So these are ways to enhance the capacity of the grid and the existing rights of way. The biggest challenge with transmission—I mean, it is expensive — but you can't get rights of way in this country and a lot of countries globally. You just cannot build a transmission line any time soon. It's a little bit different in China, they decide the line needs to go from point A to point B, they draw the shortest line, and there it goes. But here in this country, it's extremely difficult to get a transmission line sited and built. You're talking at least a decade, I think, to build a new transmission line.

Now, we can do some things with HVDC and underground cables, but underground cables may cost more money. But the good news is, you don't see them once they're installed and the right of way requirements are reduced. And the limitation—a high voltage DC cable can move basically a gigawatt of power as far as you would want to go—400, 500 miles. Two cables, roughly five or six inches in diameter. You bury them and you've got the equivalent of a long extension cord for a nuclear power plant.

Mike Telson: He wants to know how much it's gonna cost, the lunch. *[Laughter]*

Gary Rackliffe: It's difficult to estimate in terms, and I wouldn't—

Mike Telson: Is it a 50 percent increase, is it a 20 percent increase, or is it minimal—1 or 2 percent? Generally?

Gary Rackliffe: Well, it's not 1 or 2 percent, but oftentimes you're not comparing apples to apples.

Mike Telson: Correct.

Gary Rackliffe: For example, let me give you an example of offshore wind. If you go 50 miles out, you cannot use an AC cable to bring that power onto shore. And you can't use overhead either. Getting an overhead transmission line into New York City would be extremely hard, which is why we are seeing more cables used to get power into New York City.

David Brown: But these cases are really complicated cases because, you know, if you can't get a transmission line sited, for instance, and you need the increased capacity, then that's much more complicated. I was asking a much simpler question about some of these hardenings of transformers and other systems that are a smaller ball. How does that translate into rate increases where—you know, it's pretty much ceteris paribus, but then you're upgrading your cyber and physical terrorism protection. That's what I was trying to get at. That's simple.

Gary Rackliffe: Yes, I guess an example, if you're looking at a hardened transformer, the incremental cost of that might be 10 percent, 15 percent. It has a design life of 40 years, so there would be a depreciation in cost recovery over that period of time, so that would have some impact on rates. I don't know what that would be, but it would be fairly limited, as an example.

Mike Telson: But the transformer is a small part of what the customer's paying.

Gary Rackliffe: That's true.

Mike Telson: So, at the end of the day, it would probably be under 1 percent, I would think, on rates—for that transformer. Obviously it's a small thing.

Gary Rackliffe: For one transformer, sure, but I'm not a rate expert and I don't even want to try and translate a transformer cost to rates. Maybe John, you want to take that one?

John Lawhorn: I'm not gonna put on a cost percentage, but what I would like to say is that we focus way too much on cost, because the cost is what you see. That's that piece that gets dangled in front of you. You lose—what's the value?

Mike Telson: Right. *[Laughter]*

John Lawhorn: You know, you see the costs, but the value—because the cost hits up front, the value can be 50, 60 years long. What's the value of having that secure supply to the year—you know, 50, 60, 70 years out? What is that value worth? And bringing those back and having a fair discussion as to the cost versus value is incredibly important.

Going back to the transmission lines—you can't build transmission in the Northeast. You can't build pipelines, or very rarely, in the Northeast. One of the issues that we see critical going forward is, to tie it back to the first panel this morning is, gas pipelines. In order to have the regulation and the ramping capability to operate the electric grid with all these intermittent products on there, the wind and solar, you're going to have to have something that's fast acting like gas turbine, or something on that order, you've got to have the pipelines, because you're going to have to collocate or locate appropriately to be able to lever off of each other.

So if—this is a very complex issue, because with the changing fleet mix, it was also stated by previous panelists that, you know, markets work fine if what you set up is what you're trying to market. Same for the transmission grid—if you need to build new transmission, it's got to be also, you're probably going to have to build new gas pipelines, and the way that they interact with each other and where they're located. You know, the majority of the population is in the Northeast, and right now, you can't add new infrastructure there except in emergencies.

Mike Telson: Right. Go ahead.

David Brown: Yeah. Let me just add just very quickly to that cost versus value proposition. I mean, one of the things that we're seeing in Illinois as we promote this legislation to save the three nuclear units is, the cost is $150,000,000.00, and people kind of, their eyes get big when they hear that.

An independent study by the state of Illinois found that those very plants provide 4,500 jobs for the state and an economic value of $1.2 billion a year. So when you look at it in that perspective, it's even more stark. The other kicker is, of course, that the state also found that if those plants go offline and have to be replaced, that the cost of replacement is even higher than that $150,000,000.00. So it's one where the policymakers are focused on the cost but not the value, by any stretch.

Mike Telson: Unfortunately, we have to end it. Before I end it, I just wanna ask, I think a question which might go into answering your question—if we had, say, a 5 percent percentage tax or we could get 5 percent on customer rates, could we provide for a vastly improved network from a security perspective? Is the answer to that—I'm not encouraging taxes, I just wanna ask the question in terms of, if we spent a little more, could it have a big effect?

My perception is yes, okay? Obviously, you have to spent to the right things and so on. Would you care to comment on that, on my supposition? I know it's charged for each one of you, so.

David Brown: Well, I think, clearly, the more you spend, the more value you get out of the system or the more reliable system. And it kinda gets back to this question about balancing reliability, affordability, and cleanliness. And so the question is, how might you allocate that 5 percent? You know, we have repeatedly said that—look, if you put a cost on carbon, then all of a sudden you get a clean mix and a reliable mix, and an affordable mix. But obviously, you get a lot of resistance to that.

Mike Telson: Okay. Alright. Well, unless there's anything else, unfortunately, we have to end. I want to thank the panelists for a very insightful discussion. Thank you.

[Applause]

Andrew Stocking: Thanks, all, for coming today. That wraps up our energy security workshop. If you have additional comments, you can e-mail energysecuritycomments@hq.doe.gov, and you can watch this online over and over and over again if you'd like at www.energy.gov/live. So thanks very much for coming today.

[End of Audio]

Appendix B: Critical Energy-Related Materials

Clean energy technologies, including wind turbines, electric vehicles, solar photovoltaic cells, and energy-efficient lighting, rely on critical materials that represent a vulnerability for the energy security of the United States. These materials have unique chemical and physical properties and include rare earth elements (REEs) as well as other elements and minerals. Their supply chains are often characterized by small global markets, lack of supplier diversity, and limited substitutability, which can lead to shortages that inhibit the widespread deployment of the clean energy technologies that rely on their use.

These critical energy-related materials represent a vulnerability for U.S. energy security. For example, China currently accounts for more than 90 percent of global rare earth production; they imposed quotas on exports in 2008. By 2011, these quotas led to a spike in the price of elements such as dysprosium and neodymium. The spike in prices prompted concerns among global technology producers, which led to efforts to reopen or develop new mines in the United States and elsewhere. In 2015, China ended its quota system after the World Trade Organization ruled it to be a violation of trade rules, and China instead required only export licenses. With increased rare earth exports from China, market prices fell precipitously, causing new mines to either close or slow their development. Such volatility in the price and availability of critical materials is costly for businesses that use those materials to manufacture technologies that generate clean energy and thus represents a threat to U.S. energy security. Efforts to diversify global supply chains and develop substitute materials would improve market conditions for consumers of these materials and enable their more efficient use.

Different clean energy technologies have different vulnerabilities to supply chain disruptions. Wind turbines and electric vehicles—including hybrid, plug-in hybrid, and all-electric vehicles—rely on magnets that use REEs. Magnets increase the efficiency of the devices and have a smaller footprint than alternative designs using induction motors. Although many electric vehicles require only a kilogram of rare earth content, each wind turbine requires several hundred kilograms per megawatt. The limited and uncertain supply of these materials has driven the market toward designs without REEs, which tend to be less reliable and less efficient. Of the 48,000 utility-scale wind turbine units currently operating in the United States, only 377 are direct-drive units that use REEs. Aggressive global deployment of electric vehicles poses a different concern. This sector is more susceptible to price volatility and the risk of market power due to supply concentration and lack of supplier diversity, a situation the auto industry acutely experienced in 1997 with respect to palladium for catalytic converters.

Although the solar industry does not rely on REEs, thin-film solar cells rely on silver, indium, gallium, and tellurium, all of which have complicated supply chain challenges. First, the lack of data on production and reserves of these critical materials complicates planning. Second, the solar industry is growing at a rate faster than the current metal supply can keep up with, particularly silver. This could exacerbate supply-demand imbalances and drive up prices. Third, there are concerns about China's market influence in the production of these critical materials, which creates uncertainty in global prices.

Another concern associated with critical materials relates to the coproduction and production of by-products during mining and purification. These materials are present in ore in very small amounts and often occur together with other metals, and thus their production can be dependent on the economic contribution of the host metal. Production of these materials sometimes creates large quantities of tailings, which must be addressed in an environmentally responsible manner before returning the ore to the mine. Ores that contain critical materials sometimes have relatively high levels of radioactive materials such as thorium, and present additional disposal risks.

Congress has attempted to pass legislation multiple times designed to strengthen the domestic supply chain for REEs. In 2011 alone, congressional leaders submitted four pieces of legislation: (1) S. 1113, the Critical Mineral Policy Act of 2011; (2) H.R. 2011, the National Strategic and Critical Minerals Policy Act of 2011; (3) S. 383, the Critical Minerals and Materials Promotion Act of 2011; and (4) H.R. 618, the Rare Earths and Critical Materials Revitalization Act. All sought to streamline the process for permitting and development of domestic supplies and assess the criticality of vital mineral elements needed to support the nation's security and economy. Although these bills failed to pass, each subsequent Congress has seen legislation put forward to address the issue. In the current Congress, S. 2012, the Energy Policy Modernization Act of 2016, contains provisions designed to improve the nation's mineral security.

In 2010, the Obama Administration established the National Science and Technology Council Subcommittee on Critical and Strategic Minerals Supply Chains (CSMSC) and tasked it with coordinating critical-materials policy development across twelve Federal agencies and recommending any risk-mitigation actions needed. The CSMSC, led and developed primarily by DOE and the U.S. Geological Survey (USGS), has developed a methodology for identifying critical materials and monitoring changes in criticality. It also informed the formation of DOE's $120 million Critical Materials Institute, led by Ames Laboratory. The institute focuses on programs that will diversify supplies, develop substitute materials, use materials more efficiently, reduce waste in manufacturing processes, and increase the adoption of recycling.

Appendix C-1: Regulatory Impact Analysis Data Sources

Spring 2016 Unified Agenda of Federal Regulatory and Deregulatory Actions, General Services Administration

Fall 2015 Unified Agenda of Federal Regulatory and Deregulatory Actions, General Services Administration

Spring 2015 Unified Agenda of Federal Regulatory and Deregulatory Actions, General Services Administration

Fall 2014 Unified Agenda of Federal Regulatory and Deregulatory Actions, General Services Administration

2015 Report to Congress on the Benefits and Costs of Federal Regulations and Agency Compliance with the Unfunded Mandates Reform Act, Office of Management and Budget, Office of Information and Regulatory Affairs

2014 Report to Congress on the Benefits and Costs of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities, Office of Management and Budget, Office of Information and Regulatory Affairs

2013 Report to Congress on the Benefits and Costs of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities, Office of Management and Budget, Office of Information and Regulatory Affairs

2012 Report to Congress on the Benefits and Costs of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities, Office of Management and Budget, Office of Information and Regulatory Affairs

2011 Report to Congress on the Benefits and Costs of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities, Office of Management and Budget, Office of Information and Regulatory Affairs

2010 Report to Congress on the Benefits and Costs of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities, Office of Management and Budget, Office of Information and Regulatory Affairs

2009 Report to Congress on the Benefits and Costs of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities, Office of Management and Budget, Office of Information and Regulatory Affairs

2008 Report to Congress on the Benefits and Costs of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities, Office of Management and Budget, Office of Information and Regulatory Affairs

2007 Report to Congress on the Benefits and Costs of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities, Office of Management and Budget, Office of Information and Regulatory Affairs

2006 Report to Congress on the Benefits and Costs of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities, Office of Management and Budget, Office of Information and Regulatory Affairs

Appendix C-2: All Final Major, Nonbudgetary Rules Potentially Relevant to Energy Security

FY	Agency	RIN	Title
2016	DOI	1014–AA11	Blowout Prevention Systems and Well Control
2016	DHS	1625–AA02	Discharge Removal Equipment for Vessels Carrying Oil
2016	DOE	1904–AC54	Energy Conservation Standards for Commercial and Industrial Pumps
2016	DOE	1904–AC85	Energy Conservation Standards for Single Package Vertical Air Conditioners and Single Package Vertical Heat Pumps
2016	DOE	1904–AC87	Energy Conservation Standards for Residential Ceiling Fan Light Kits
2016	DOE	1904–AC88	Energy Conservation Standards for Residential Boilers
2016	DOE	1904–AC95	Energy Conservation Standards for Small, Large, and Very Large Commercial Package A/C and Heating Equipment
2016	DOE	1904–AD00	Energy Conservation Standards for Refrigerated Bottled or Canned Beverage Vending Machines
2016	DOE	1904–AD11	Energy Conservation Standards for Commercial Warm Air Furnaces
2016	DOE	1904–AD31	Energy Conservation Standards for Commercial Pre-Rinse Spray Valves
2016	EPA	2040-AF14	Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category
2016	EPA	2060-AP38	Revisions to the National Ambient Air Quality Standards for Ground-Level Ozone
2016	EPA	2060-AQ75	Petroleum Refinery Sector Risk and Technology Review and New Source Performance Standards
2016	EPA	2060-AS30	Oil and Natural Gas Sector: Emission Standards for New and Modified Sources
2016	DOT	2126–AB20	Electronic Logging Devices and Hours of Service Supporting Documents (MAP–21)
2015	USDA	0570–AA76	Rural Energy for America Program
2015	USDA	0570–AA93	Biorefinery, Renewable Chemical, and Biobased Product Manufacturing Assistance Program
2015	DHS	1625–AA99	Vessel Requirements for Notices of Arrival and Departure, and Automatic Identification System
2015	DOE	1904-AC39	Energy Efficiency Standards for Automatic Commercial Ice Makers
2015	EPA	2040-AF30	Definition of "Waters of the United States" under the Clean Water Act
2015	EPA	2050-AE81	Standards for the Management of Coal Combustion Residuals Generated by Commercial Electric Power Producers

2015	EPA	2050-AG46	Revising Underground Storage Tank Regulations—Revisions to Existing Requirements and New Requirements for Secondary Containment and Operator Training
2015	EPA	2060-AP69	Brick and Structural Clay Products NESHAP
2015	EPA	2060-AP93	Residential Wood Heaters NSPS Revision
2015	EPA	2060-AQ91	Standards of Performance for Greenhouse Gas Emissions from New, Modified, and Reconstructed Stationary Sources: Electric Utility Generating Units
2015	EPA	2060-AR33	Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units (Clean Power Plan)
2015	DOT	2127-AK97	Electronic Stability Control Systems for Heavy Vehicles (MAP–21)
2015	DOT	2137-AE91	Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains
2014	DOE	1904-AB57	Energy Efficiency Standards for External Power Supplies
2014	DOE	1904-AB86	Energy Conservation Standards for Walk-In Coolers and Walk-In Freezers
2014	DOE	1904-AC00	Energy Efficiency Standards for Metal Halide Lamp Fixtures
2014	DOE	1904-AC19	Energy Conservation Standards for Commercial Refrigeration Equipment
2014	DOE	1904-AC22	Energy Conservation Standards for Residential Furnace Fans
2014	DOE	1904-AC28	Energy Efficiency Standards for Certain Commercial and Industrial Electric Motors
2014	EPA	2040-AE95	Criteria and Standards for Cooling Water Intake Structures
2014	EPA	2060-AQ86	Control of Air Pollution from Motor Vehicles: Tier 3 Motor Vehicle Emission and Fuel Standards
2013	USDA	0560-AH86	Feedstock Flexibility Program
2013	DOE	1904-AC04	Energy Efficiency Standards for Distribution Transformers
2013	DOE	1904-AC07	Energy Efficiency Standards for Microwave Ovens (Standby and Off Mode)
2013	EPA	2060-AO47	Review of the National Ambient Air Quality Standards for Particulate Matter
2013	EPA	2060-AQ58	Reconsideration of Final National Emission Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines
2013	EPA	2060-AR13	National Emission Standards for Hazardous Air Pollutants for Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters; Proposed Reconsideration
2012	DOI	1014-AA02	Increased Safety Measures for Oil and Gas Operations on the Outer Continental Shelf (OCS)

2012	DHS	1625-AA32	Standards for Living Organisms in Ships' Ballast Water Discharged in U.S. Waters
2012	DOE	1904-AB50	Energy Efficiency Standards for Fluorescent Lamp Ballasts
2012	DOE	1904-AB90	Energy Conservation Standards for Residential Clothes Washers
2012	EPA	2060-AN72	Petroleum Refineries—New Source Performance Standards (NSPS)—Subparts J and Ja
2012	EPA	2060-AP52	National Emission Standards for Hazardous Air Pollutants from Coal- and Oil-Fired Electric Utility Steam Generating Units and Standards of Performance for Electric Utility Steam Generating Units
2012	EPA	2060-AP76	Oil and Natural Gas Sector—New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants
2012	EPA	2060-AQ54	Joint Rulemaking to Establish 2017 and Later Model Year Light Duty Vehicle GHG Emissions and CAFE Standards
2012	DOT	2126-AB26	Hours of Service
2012	DOT	2127-AK79	Passenger Car and Light Truck Corporate Average Fuel Economy Standards MYs 2017 and Beyond (RRR)
2012	DOT	2130-AC27	Positive Train Control Systems Amendments (RRR)
2011	DOI	1010-AD68	Increased Safety Measures for Oil and Gas Operations on the Outer Continental Shelf (OCS)
2011	DOE	1904-AA89	Energy Efficiency Standards for Clothes Dryers and Room Air Conditioners
2011	DOE	1904-AB79	Energy Efficiency Standards for Residential Refrigerators, Refrigerator-Freezers, and Freezers
2011	DOE	1904-AC06	Energy Efficiency Standards for Residential Furnace, Central Air Conditioners and Heat Pumps
2011	EPA	2060-AP50	Cross-State Air Pollution Rule (CAIR Replacement Rule)
2011	EPA & DOT	2060-AP61	Commercial Medium- and Heavy-Duty On-Highway Vehicles and Work Truck Fuel Efficiency Standards
2011	DOT	2125-AF19	Real-Time System Management Information Program
2010	DOE	1904-AA90	Energy Efficiency Standards for Pool Heaters and Direct Heating Equipment and Water Heaters
2010	DOE	1904-AB70	Energy Conservation Standards for Small Electric Motors
2010	DOE	1904-AB93	Energy Efficiency Standards for Commercial Clothes Washers
2010	EPA	2050-AG16	Revisions to the Spill Prevention, Control, and Countermeasure (SPCC) Rule
2010	EPA	2060-AO15	NESHAP: Portland Cement Notice of Reconsideration
2010	EPA	2060-AO38	Control of Emissions from New Marine Compression-Ignition Engines at or above 30 Liters per Cylinder

2010	EPA	2060-AO48	Review of the National Ambient Air Quality Standards for Sulfur Dioxide
2010	EPA	2060-AO81	Renewable Fuels Standard Program
2010	EPA	2060-AP36	National Emission Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines (Diesel)
2010	EPA	2060-AP86	Prevention of Significant Deterioration/Title V Greenhouse Gas Tailoring Rule
2010	EPA	2127-AK50	Light-Duty Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards
2010	EPA	2060-AQ13	National Emission Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines—Existing Stationary Spark Ignition (Gas-Fired)
2010	DOT	2126-AA89	Electronic On-Board Recorders for Hours-of-Service Compliance
2010	DOT	2060AP58	Light-Duty Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards
2010	DOT	2130-AC03	Positive Train Control
2010	DOT	2137-AE15	Pipeline Safety: Distribution Integrity Management
2009	DHS	1651-AA70	Importer Security Filing and Additional Carrier Requirements
2009	DOE	1904-AA92	Energy Efficiency Standards for General Service Fluorescent Lamps and Incandescent Lamps
2009	DOE	1904-AB59	Energy Efficiency Standards for Commercial Refrigeration Equipment
2009	EPA	2060-AN83	Review of the National Ambient Air Quality Standards for Lead
2009	EPA	2060-AO79	Greenhouse Gas Mandatory Reporting Rule
2009	DOT	2120-AI17	Washington, DC, Metropolitan Area Special Flight Rules Area
2009	DOT	2126-AB14	Hours of Service of Driver
2009	DOT	2127-AG51	Roof Crush Resistance
2009	DOT	2127-AJ37	Reduced Stopping Distance Requirements for Truck Tractors
2009	DOT	2127-AK29	Passenger Car and Light Truck Corporate Average Fuel Economy Model Year 2011
2009	DOT	2127-AK53	Requirements for Temporary Vehicle Trade-In Program
2009	DOT	2137-AE25	Pipeline Safety: Standards for Increasing the Maximum Allowable Operating Pressure for Gas Transmission Pipelines
2008	DOC	0648-AS36	Right Whale Ship Strike Reduction
2008	DOE	1904-AA78	Energy Efficiency Standards for Residential Furnaces and Boilers
2008	EPA	2050-AG31	Definition of Solid Wastes Revisions
2008	EPA	2060-AM06	Control of Emissions from New Locomotives and New Marine Diesel Engines Less Than 30 Liters per Cylinder

2008	EPA	2060-AM34	Control of Emissions from Nonroad Spark Ignition Engines and Equipment
2008	EPA	2060-AN24	Review of the National Ambient Air Quality Standards for Ozone
2008	EPA	2060-AN72	Petroleum Refineries—New Source Performance Standards (NSPS)—Subpart J
2008	DOT	2120-AI23	Transport Airplane Fuel Tank Flammability Reduction
2008	DOT	2130-AB84	Regulatory Relief for Electronically Controlled Pneumatic Brake System Implementation
2007	DHS	1601-AA41	Chemical Facility Anti-Terrorism Standards
2007	DHS	1652-AA41	Transportation Worker Identification Credential (TWIC) Implementation in the Maritime Sector
2007	DOE	1904-AB08	Energy Efficiency Standards for Electric Distribution Transformers
2007	EPA	2050-AG23	Oil Pollution Prevention; Spill Prevention, Control, and Countermeasure (SPCC) Requirements—Amendments
2007	EPA	2060-AK70	Control of Hazardous Air Pollutants from Mobile Sources
2007	DOT	2127-AJ77	Electronic Stability Control
2006	EPA	2040-AD38	National Primary Drinking Water Regulations: Stage 2 Disinfection Byproducts Rule
2006	EPA	2060-AI44	Review of the National Ambient Air Quality Standards (NAAQS) for Particulate Matter
2006	EPA	2060-AM82	Standards of Performance for Stationary Compression Ignition Internal Combustion Engines
2006	DOT	2120-AI51	Congestion and Delay Reduction at Chicago O'Hare International Airport
2006	DOT	2127-AJ61	Average Fuel Economy Standards for Light Trucks Model Years 2008-11
2005	EPA	2040-AD37	National Primary Drinking Water Regulations: Long Term 2 Enhanced Surface Water Treatment Rule
2005	EPA	2060-AJ31	Clean Air Visibility Rule: Best Available Retrofit Technology (BART)
2005	EPA	2060-AJ65	Clean Air Mercury Rule—Electric Utility Steam Generating Units
2005	EPA	2060-AL76	Clean Air Interstate Rule
2005	DOT	2126-AA90	Hours of Service of Drivers
2005	DOT	2127-AJ23	Tire Pressure Monitoring Systems

Appendix C-3: All Final Major Rules Unrelated to Energy Security or Budgetary Transfer

FY	Agency	RIN	Title
2016	USDA	0551–AA87	USDA Local and Regional Food Aid Procurement Program
2016	USDA	0560–AI31	Payment Limitation and Payment Eligibility—Actively Engaged in Farming
2016	USDA	0570–AA85	Business and Industry (B&I) Guaranteed Loan Program
2016	USDA	0572–AC34	Rural Broadband Access Loans and Loan Guarantees
2016	USDA	0578–AA62	Environmental Quality Incentives Program (EQIP)
2016	USDA	0578–AA63	Conservation Stewardship Program
2016	USDA	0579–AD77	User Fees for Agricultural Quarantine and Inspection Services
2016	USDA	0583–AD36	Mandatory Inspection of Fish of the Order Siluriformes and Products Derived from Such Fish
2016	USDA	0583–AD41	Electronic Export Application and Certification as a Reimbursable Service and Flexibility in the Requirements for Official Export Inspection Marks, Devices, and Certificates
2016	USDA	0583–AD46	Records to Be Kept by Official Establishments and Retail Stores That Grind Raw Beef Products
2016	USDA	0584–AE18	Child and Adult Care Food Program: Meal Pattern Revisions Related to the Healthy, Hunger-Free Kids Act of 2010
2016	USDA	0584–AE33	SNAP: Employment and Training (E&T) Performance Measurement, Monitoring and Reporting Requirements
2016	USDA	0596–AC82	Forest Service Manual 2020—Ecological Restoration and Resilience Policy
2016	USDA	0596–AD14	Ski Area—D Clauses: Resource and Improvement Protection, Water Facilities, and Water Rights
2016	DOC	0648–AS65	Fishery Management Plan for Regulating Offshore Marine Aquaculture in the Gulf of Mexico
2016	DOC	0648–AS65	Fishery Management Plan for Regulating Offshore Marine Aquaculture in the Gulf of Mexico
2016	DOC	0648–AY54	Designation of Critical Habitat for the North Atlantic Right Whale
2016	DOC	0648–BA17	Atlantic Highly Migratory Species; Future of the Atlantic Shark Fishery
2016	DOC	0648–BB02	Implement the 2010 Shark Conservation Act Provisions and Other Regulations in the Atlantic Smoothhound Shark Fishery
2016	DOC	0648–BB30	Endangered and Threatened Species: Designation of Critical Habitat for Threatened Lower Columbia River Coho Salmon and Puget Sound Steelhead

2016	DOC	0648–BD54	Implementation of the Inter-American Tropical Tuna Commission Resolution to Establish a Vessel Monitoring System Program in the Eastern Pacific Ocean
2016	DOC	0648–BD76	Amendment 7 to the FMP for the Dolphin Wahoo Fishery of the Atlantic and Amendment 33 to the FMP for the Snapper-Grouper Fishery of the South Atlantic
2016	DOC	0648–BD81	Amendment 8 to the Fishery Management Plan for Coral, Coral Reefs, and Live/Hard Bottom Habitats of the South Atlantic Region
2016	DOC	0648–BD97	Revisions to Hawaiian Islands Humpback Whale National Marine Sanctuary Regulations
2016	DOC	0648–BE05	Cost Recovery from Amendment 80, CDQ Groundfish and Halibut, American Fisheries Act and Aleutian Islands Pollock, and the Freezer Longline Coalition Pacific Cod Fisheries Management Programs
2016	DOC	0648–BE38	Generic Accountability Measure and Dolphin Allocation Amendment for the South Atlantic Region
2016	DOC	0648–BE84	International Fisheries; Western and Central Pacific Fisheries for Highly Migratory Species; Fishing Effort and Catch Limits and other Restrictions and Requirements
2016	DOC	0648–BE85	Revision of Skate Maximum Retainable Amounts in the Gulf of Alaska Groundfish Fishery
2016	DOC	0648–BE98	Amendment 44 to the Fishery Management Plan for Bering Sea/Aleutian Islands King and Tanner Crabs to Modify Right of First Refusal Provisions of the Crab Rationalization Program
2016	DOC	0648–BF14	Framework Amendment 3 to the Fishery Management Plan for the Coastal Migratory Pelagic Resources of the Gulf of Mexico and Atlantic Region
2016	DOC	0648–BF21	Framework Amendment to the Fishery Management Plan for the Reef Fish Resources of the Gulf of Mexico to Modify Greater Amberjack Allowable Harvest and Management Measures
2016	DOC	0648–BF33	Framework Amendment to the Fishery Management Plan for the Reef Fish Resources of the Gulf of Mexico for Red Snapper Commercial Quota Retention for 2016
2016	DOD	0750–AI61	Network Penetration Reporting and Contracting for Cloud Services (DFARS Case 2013–D018)
2016	DOD	0790–AI19	Service Academies
2016	DOD	0790–AJ17	Transition Assistance Program (TAP) for Military Personnel
2016	DOD	0790–AJ29	Department of Defense (DoD)-Defense Industrial Base (DIB) Cybersecurity (CS) Activities
2016	DHS	1615–AC00	Enhancing Opportunities for H–1B1, CW–1, and E–3 Nonimmigrants and EB–1 Immigrants
2016	DHS	1652–AA67	Passenger Screening Using Advanced Imaging Technology

2016	DHS	1652–AA67	Passenger Screening Using Advanced Imaging Technology
2016	DHS	1653–AA72	Improving and Expanding Training Opportunities for F–1 Nonimmigrant Students with STEM Degrees and Cap-Gap Relief for All Eligible F–1 Students (Completion of a Section 610 Review)
2016	EPA	2040–AF58	Section 610 Review of National Primary Drinking Water Regulations: Ground Water Rule (Completion of a Section 610 Review)
2016	EPA	2070–AJ22	Pesticides; Agricultural Worker Protection Standard Revisions
2016	DOT	2120–AJ60	Operation and Certification of Small Unmanned Aircraft Systems
2016	DOT	2120–AK08	Flight Simulation Training Device Qualification Standards for Extended Envelope and Adverse Weather Event Training (International Cooperation)
2016	DOT	2125–AF49	National Goals and Performance Management Measures (MAP–21)
2016	DOT	2135–AA38	Tariff of Tolls (Rulemaking Resulting from a Section 610 Review)
2016	DOT	2135-AA39	Seaway Regulations and Rules: Periodic Update, Various Categories (Rulemaking Resulting from a Section 610 Review)
2015	USDA	0560–AI20	Noninsured Crop Disaster Assistance Program
2015	USDA	0560–AI26	Conservation Compliance
2015	USDA	0560–AI30	Conservation Reserve Program (CRP)
2015	USDA	0578–AA61	Agricultural Conservation Easement Program
2015	USDA	0579–AD41	Importation of Beef from a Region in Brazil
2015	USDA	0579–AD64	Viruses, Serums, Toxins, and Analogous Products; Single Label Claim for Veterinary Biological Products
2015	USDA	0579–AD92	Importation of Beef from a Region in Argentina (Section 610 Review)
2015	USDA	0583–AD45	Descriptive Designation for Needle- or Blade-Tenderized (Mechanically Tenderized) Beef Products
2015	USDA	0596–AD06	Land Management Planning Rule Policy
2015	DOC	0648–BA81	Revision of Hawaiian Monk Seal Critical Habitat
2015	DOD	0720–AB60	CHAMPUS/TRICARE: Withdrawal of Pilot Program for Refills of Maintenance Medications for TRICARE For Life Beneficiaries through the TRICARE Mail Order Program
2015	DOD	0750–AI32	Foreign Commercial Satellite Services (DFARS Case 2014–D010)
2015	DOI	1018–AV68	Injurious Wildlife Species; Constrictor Species from Python, Boa, and Eunectes Genera
2015	DHS	1615–AB92	Employment Authorization for Certain H–4 Dependent Spouses
2015	DHS	1651–AA72	Changes to the Visa Waiver Program to Implement the Electronic System for Travel Authorization (ESTA) Program

2015	DHS	1653–AA63	Adjustments to Limitations on Designated School Official Assignment and Study by F–2 and M–2 Nonimmigrants
2015	EPA	2040–AF16	Water Quality Standards Regulatory Revisions
2015	EPA	2060–AR34	Implementation of the 2008 National Ambient Air Quality Standards for Ozone: State Implementation Plan Requirements
2015	DOT	2120–AJ86	Safety Management Systems for Certificate Holders
2015	DOT	2120–AK60	Prohibition Against Certain Flights Within the Baghdad (ORBB) Flight Information Region (FIR) Amendment
2015	DOT	2126-AB44	Lease and Interchange of Vehicles; Motor Carriers of Passengers
2015	DOT	2126-AB46	Inspection, Repair, and Maintenance; Driver-Vehicle Inspection Report (RRR)
2015	DOT	3150–AJ44	Revision of Fee Schedules: Fee Recovery for FY 2015 [NRC–2014–0200]
2014	USDA	0560-AI21	Disaster Assistance Programs, Payment Limitations, and Payment Eligibility
2014	USDA	0560-AI22	Cotton Transition Assistance Program (CTAP)
2014	USDA	0560-AI23	Margin Protection Program for Dairy and Dairy Product Donation Program
2014	USDA	0563–AC43	General Administrative Regulations; Catastrophic Risk Protection Endorsement; Area Risk Protection Insurance Regulations; and the Common Crop Insurance Regulations, Basic Provisions
2014	USDA	0584-AD77	Special Supplemental Nutrition Program for Women, Infants, and Children (WIC): Revisions in the WIC Food Packages
2014	USDA	0584-AE15	Certification of Compliance With Meal Requirements for the National School Lunch Program Under the Healthy, Hunger-Free Kids Act of 2010
2014	DOC	0648-BB20	Eliminate the Expiration Date Contained in the Final Rule to Reduce the Threat of Ship Collisions With North Atlantic Right Whales
2014	DOD	0720-AB60	CHAMPUS/TRICARE: Pilot Program for Refills of Maintenance Medications for TRICARE For Life Beneficiaries Through the TRICARE Mail Order Program
2014	DOD	0790-AJ06	Voluntary Education Programs
2014	DOI	1018-AZ80	Migratory Bird Hunting; 2014–2015 Migratory Game Bird Hunting Regulations (Early Season)
2014	DOI	1018-AZ80	Migratory Bird Hunting; 2014–2015 Migratory Game Bird Hunting Regulations (Late Season)
2014	DHS	1652-AA01	Aviation Security Infrastructure Fees (ASIF)
2014	DHS	1652-AA68	Adjustment of Passenger Civil Aviation Security Service Fee
2014	DOT	2127-AK43	Federal Motor Vehicle Safety Standard No. 111, Rearview Mirrors

2014	DOT	2127-AK56	Require Installation of Seat Belts on Motorcoaches, FMVSS No. 208 (MAP-21)
2013	USDA	0572AC06	Rural Broadband Access Loans and Loan Guarantees
2013	USDA	0572AC19	Energy Efficiency Program Loans
2013	USDA	0581AD29	Mandatory Country of Origin Labeling of Beef, Pork, Lamb, Chicken, Goat Meat, Perishable Agricultural Commodities, Peanuts, Pecans, Macadamia Nuts, Ginseng, etc., LS-13-0004
2013	USDA	0584AE07	Supplemental Nutrition Assistance Program: Nutrition Education and Obesity Prevention Grant
2013	USDA	0584AE09	National School Lunch and School Breakfast Programs: Nutrition Standards for All Foods Sold in School, as Required by the Healthy, Hunger-Free Kids Act of 2010
2013	DOC	0651AC54	Setting and Adjusting Patent Fees
2013	DOD	0720AB41	TRICARE; Reimbursement of Sole Community Hospitals
2013	DOD	0790AI50	Voluntary Education Programs
2013	DOI	1018AY87	Migratory Bird Hunting; 2013–2014 Migratory Game Bird Hunting Regulations (Early Season)
2013	DOI	1018AY87	Migratory Bird Hunting; 2013–2014 Migratory Game Bird Hunting Regulations (Late Season)
2013	DHS	1615AB99	Provisional Unlawful Presence Waivers of Inadmissibility for Certain Immediate Relatives
2013	DOT	2120AJ67	Pilot Certification and Qualification Requirements (Formerly First Officer Qualification Requirements) (HR 5900)
2013	DOT	2127AL30	Uniform Procedures for State Highway Safety Programs
2013	DOT	2132AB02	Major Capital Investment Projects (RRR)
2013	DOT	2132AB13	Public Transportation Emergency Relief Program
2012	USDA	0584-AD59	Nutrition Standards in the National School Lunch and School Breakfast Programs
2012	USDA	0584-AE15	Certification of Compliance with Meal Requirements for the National School Lunch Program under the Healthy, Hunger-Free Kids Act of 2010
2012	DOI	1018-AX97	Migratory Bird Hunting; 2012–2013 Migratory Game Bird Hunting Regulations—Early Season
2012	DOI	1018-AX97	Migratory Bird Hunting; 2012–2013 Migratory Game Bird Hunting Regulations—Late Season
2012	DOT	2126-AA97	National Registry of Certified Medical Examiners
2011	USDA	0560-AH92	Biomass Crop Assistance Program
2011	USDA	0560-AI11	Crop Assistance Program
2011	USDA	0570-AA73	Biorefinery Assistance Program—Section 9003

2011	USDA	0570-AA75	Rural Business Contracts for Payments for the Bioenergy Program for Advanced Biofuels—Section 9005
2011	USDA	0572-AC06	Rural Broadband Access Loans and Loan Guarantees
2011	USDA	0584-AD60	Direct Certification of Children in Food Stamp Households and Certification of Homeless, Migrant, and Runaway Children for Free Meals in the NSLP, SBP, and SMP
2011	USDA	0584-AE11	National School Lunch and School Breakfast Programs: School Food Service Account Revenue Amendments Related to the Healthy, Hunger-Free Kids Act of 2010
2011	DOD	0720-AB45	Civilian Health and Medical Program of the Uniformed Services (CHAMPUS)/TRICARE: Inclusion of TRICARE Retail Pharmacy Program in Federal Procurement of Pharmaceuticals
2011	DOD	0790-AI58	Homeowners Assistance Program (HAP)
2011	DOI	1018-AX34	Migratory Bird Hunting; 2011-12 Migratory Game Bird Hunting Regulations, Early Season
2011	DOI	1018-AX34	Migratory Bird Hunting; 2011-12 Migratory Game Bird Hunting Regulations, Late Season
2011	EPA	2040-AF11	Water Quality Standards (Numeric Nutrient Criteria) for Florida's Lakes and Flowing Waters
2011	EPA	2050-AG50	Oil Pollution Prevention: Spill Prevention, Control, and Countermeasure Rule Requirements–Amendments for Milk Containers
2011	DOT	2127-AK23	Ejection Mitigation
2010	USDA	0560-AH90	Supplemental Revenue Assistance Payments Program (SURE)
2010	USDA	0560-AI07	Dairy Economic Loss Assistance Payment Program
2010	USDA	0578-AA43	Conservation Stewardship Program
2010	USDA	0584-AD30	SNAP: Eligibility and Certification Provisions of the Farm Security and Rural Investment Act of 2002
2010	DOC	0660-ZA28	Broadband Technology Opportunities Program
2010	DOD	0720-AB17	TRICARE: Relationship between the TRICARE Program and Employer-Sponsored Group Health Coverage
2010	DOD	0790-AI59	Retroactive Stop Loss Special Pay Compensation
2010	DOI	1018-AX06	Migratory Bird Hunting; Final Frameworks for Early-Season Migratory Bird Hunting Regulations
2010	DOI	1018-AX06	Migratory Bird Hunting; Final Frameworks for Late Season Migratory Bird Hunting Regulations
2010	DOS	1400-AC58	Schedule of Fees for Consular Services, Department of State and Overseas Embassies and Consulates
2010	DHS	1615-AB80	U. S. Citizenship and Immigration Services Fee Schedule

2010	DHS	1651-AA83	Electronic System for Travel Authorization (ESTA): Fee for Use of the System
2010	DHS	1660-AA44	Special Community Disaster Loans Program
2010	DOE	1901-AB27	Loan Guarantees for Projects That Employ Innovative Technologies
2010	DOE	1904-AB97	Weatherization Assistance Program for Low Income Persons—Multi-unit Buildings
2010	DOT	2120-AI92	Automatic Dependent Surveillance-Broadcast (ADS-B) Equipage Mandate to Support Air Traffic Control Service
2009	USDA	0560-AH80	Conservation Reserve Program
2009	USDA	0560-AH84	Direct and Counter-Cyclical Program (DCP)
2009	USDA	0560-AH86	Sugar Program
2009	USDA	0560-AH87	Marketing Assistance Loans and Loan Deficiency Payments
2009	USDA	0560-AH93	Emergency Loss Assistance Program (ELAP) and Livestock Forage Disaster Program (LFP)
2009	USDA	0578-AA43	Conservation Stewardship Program
2009	USDA	0578-AA45	Environmental Quality Incentives Program
2009	USDA	0578-AA47	Wetlands Reserve Program
2009	USDA	0581-AC26	Mandatory Country of Origin Labeling of Beef, Pork, Lamb, Fish, Perishable Agricultural Commodities, and Peanuts (LS-07-0081)
2009	DOC	0660-AA19	Regulations to Implement the DTV Delay Act
2009	DOC	0660-ZA29	State Broadband Data and Development Grant Program
2009	DOD	0720-AB19	TRICARE; Outpatient Hospital Prospective Payment System (OPPS)
2009	DOD	0720-AB22	CHAMPUS/TRICARE: Inclusion of TRICARE Retail Pharmacy Program in Federal Procurement of Pharmaceuticals
2009	DOI	1004-AD90	Oil Shale Leasing and Operations
2009	DOI	1010-AD30	Alternative Energy and Alternate Uses of Existing Facilities on the Outer Continental Shelf
2009	DOI	1018-AW31	Migratory Bird Hunting; 2009 to 2010 Migratory Game Bird Hunting Regulations
2009	DOI	1029-AC56	Abandoned Mine Land Program
2009	DHS	1615-AB72	Documents and Receipts Acceptable for Employment Eligibility Verification
2009	DHS	1652-AA45	Secure Flight Program
2009	DHS	1652-AA64	Air Cargo Screening
2009	DOE	1901-AB25	Advanced Technology Vehicles Manufacturing Incentive Program

2009	DOE	1901-ZA01	Energy Efficiency and Conservation Block Grants; Notice of Allocation Formulas
2009	DOE	1904-AB73	Production Incentives for Cellulosic Biofuels
2009	DOT	2120-AJ01	Part 121 Pilot Age Limit
2009	DOT	2126-AA59	New Entrant Safety Assurance Process
2008	DOI	1018-AV62	Migratory Bird Hunting; 2008 to 2009 Migratory Game Bird Hunting Regulations
2008	DHS	1601-AA37	Minimum Standards for Driver's Licenses and Identification Cards Acceptable by Federal Agencies for Official Purposes
2008	DHS	1651-AA69	Documents Required for Travelers Entering the United States at Sea and Land Ports-of-Entry from Within the Western Hemisphere
2008	DHS	1651-AA72	Changes to the Visa Waiver Program to Implement the Electronic System for Travel Authorization (ESTA) Program
2008	EPA	2070-AC83	Lead-Based Paint; Amendments for Renovation, Repair and Painting
2007	USDA	0579-AC01	Bovine Spongiform Encephalopathy (BSE); Minimal Risk Regions and Importation of Commodities
2007	USDA	0583-AC88	Prohibition of the Use of Specified Risk Materials for Human Food and Requirements for the Disposition of Non-Ambulatory Disabled Cattle
2007	DOI	1018-AV12	Migratory Bird Hunting; 2007 to 2008 Migratory Game Bird Hunting Regulations: Early Season
2007	DOI	1018-AV12	Migratory Bird Hunting; 2007 to 2008 Migratory Game Bird Hunting Regulations: Late season
2007	DHS	1651-AA62	Passenger Manifest for Commercial Aircraft and Vessels Arriving In and Departing from the United States
2007	DHS	1651-AA66	Documents Required for Travel within the Western Hemisphere
2007	DOT	2127-AJ10	Side Impact Protection
2006	DOI	1018-AU42	Migratory Bird Hunting; 2006–2007 Migratory Game Bird Hunting Regulations: Early Season
2006	DOI	1018-AU42	Migratory Bird Hunting; 2006–2007 Migratory Game Bird Hunting Regulations: Late Season
2006	DHS	1652-AA23	Air Cargo Security Requirements
2005	USDA	0579-AB73	Bovine Spongiform Encephalopathy: Minimal Risk Regions and Importation of Commodities
2005	USDA	0579-AB81	Mexican Hass Avocado Import Program
2005	DOC	0648-AQ77	Designate Critical Habitat for 13 Evolutionarily Significant Units (ESUs) of Pacific Salmon and Steelhead in Washington, Oregon and Idaho

2005	DOD1	0648-AS47	Amendments 18 and 19 to the Fishery Management Plan for Bering Sea/Aleutian Islands King and Tanner Crabs—Crab Rationalization Program
2005	DOI	1018-AT76	Migratory Bird Hunting; 2005–2006 Migratory Game Bird Hunting Regulations: Early Season
2005	DOI	1018-AT76	Migratory Bird Hunting; 2005–2006 Migratory Game Bird Hunting Regulations: Late Season
2005	DHS	1651-AA37	Electronic Transmission of Passenger and Crew Manifests for Vessels and Aircraft
2005	DOT	2127-AH09	Upgrade of Head Restraints
2005	DOT	2127-AI91	Occupant Crash Protection: Rear Center Lap/Shoulder Belt Requirement—Standard 208

Appendix C-4: Monopsony Component of Selected RIAs

FY	Agency	Title	Monopsony
2012	EPA	Joint Rulemaking to Establish 2017 and Later Model Year Light Duty Vehicle GHG Emissions and CAFE Standards	$9.77/barrel (2010$) in 2025
2012	DOT	Passenger Car and Light Truck Corporate Average Fuel Economy Standards MYs 2017 and Beyond	$9.77/barrel (2010$) in 2025
2011	EPA & DOT	Commercial Medium- and Heavy-Duty On-Highway Vehicles and Work Truck Fuel Efficiency Standards	$11.29/barrel (2009$) in 2020
2010	EPA	Renewable Fuels Standard Program	$7.86/barrel oil + ethanol or $7.88/barrel just oil (2007$) in 2022
2010	EPA	Light-Duty Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards	$12.31/barrel (2007$) in 2020
2010	DOT	Light-Duty Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards	$12.50/barrel (2007$)
2009	DOT	Passenger Car and Light Truck Corporate Average Fuel Economy Model Year 2011	$11.17/barrel (2007$)*
2006	DOT	Average Fuel Economy Standards for Light Trucks Model Years 2008–11	$1.85/barrel (2003$)*

Impact categories: A number indicates that the impact was quantified.

* The impact was included in the final cost-benefit analysis (otherwise, it was excluded from the final calculations).

Appendix C-5: Other EPA RIAs with a Qualitative Discussion of Climate Change Effects

FY	Agency	Title	GHGs	Direction of GHG Impact
2016	EPA	Revisions to the National Ambient Air Quality Standards for Ground-Level Ozone	Qualitative (tropospheric ozone)	Reduces
2015	EPA	Residential Wood Heaters NSPS Revision	Qualitative (black carbon)	Reduces
2013	EPA	Review of the National Ambient Air Quality Standards for Particulate Matter	Qualitative (black carbon)	Reduces
2010	EPA	Prevention of Significant Deterioration/Title V Greenhouse Gas Tailoring Rule	Qualitative (carbon dioxide)	Reduces
2009	EPA	Greenhouse Gas Mandatory Reporting Rule	Qualitative (carbon dioxide)	None
2008	EPA	Review of the National Ambient Air Quality Standards for Ozone	Qualitative (tropospheric ozone)	Reduces

Impact categories: "Qualitative" indicates the impact was qualitatively described, but no quantitative estimate was included.

Appendix C-6: Residual Rules

FY	Agency	RIN	Title
2016	DOI	1014–AA11	Blowout Prevention Systems and Well Control
2016	DHS	1625–AA02	Discharge Removal Equipment for Vessels Carrying Oil
2016	DOT	2126–AB20	Electronic Logging Devices and Hours of Service Supporting Documents (MAP–21)
2015	USDA	0570–AA76	Rural Energy for America Program
2015	USDA	0570–AA93	Biorefinery, Renewable Chemical, and Biobased Product Manufacturing Assistance Program
2015	DHS	1625–AA99	Vessel Requirements for Notices of Arrival and Departure, and Automatic Identification System
2015	DOT	2127-AK97	Electronic Stability Control Systems for Heavy Vehicles (MAP–21)
2015	EPA	2050-AG46	Revising Underground Storage Tank Regulations—Revisions to Existing Requirements and New Requirements for Secondary Containment and Operator Training
2013	USDA	0560AH86	Feedstock Flexibility Program
2012	DHS	1625-AA32	Standards for Living Organisms in Ships' Ballast Water Discharged in U.S. Waters
2012	DOT	2126-AB26	Hours of Service
2012	DOT	2130-AC27	Positive Train Control Systems Amendments (RRR)
2011	DOI	1010-AD68	Increased Safety Measures for Oil and Gas Operations on the Outer Continental Shelf (OCS)
2010	EPA	2050-AG16	Revisions to the Spill Prevention, Control, and Countermeasure (SPCC) Rule
2010	EPA	2060-AO48	Review of the National Ambient Air Quality Standards for Sulfur Dioxide
2010	EPA	2060-AP36	National Emission Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines (Diesel)
2010	EPA	2060-AQ13	National Emission Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines—Existing Stationary Spark Ignition (Gas-Fired)
2010	DOT	2126-AA89	Electronic On-Board Recorders for Hours-of-Service Compliance
2010	DOT	2137-AE15	Pipeline Safety: Distribution Integrity Management
2009	DHS	1651-AA70	Importer Security Filing and Additional Carrier Requirements
2009	EPA	2060-AN83	Review of the National Ambient Air Quality Standards for Lead

2009	DOT	2120-AI17	Washington, DC, Metropolitan Area Special Flight Rules Area
2009	DOT	2126-AB14	Hours of Service of Driver
2009	DOT	2127-AJ37	Reduced Stopping Distance Requirements for Truck Tractors
2009	DOT	2137-AE25	Pipeline Safety: Standards for Increasing the Maximum Allowable Operating Pressure for Gas Transmission Pipelines
2008	DOC	0648-AS36	Right Whale Ship Strike Reduction
2008	EPA	2050-AG31	Definition of Solid Wastes Revisions
2008	EPA	2060-AN72	Petroleum Refineries—New Source Performance Standards (NSPS)—Subpart J
2008	DOT	2120-AI23	Transport Airplane Fuel Tank Flammability Reduction
2007	DHS	1601-AA41	Chemical Facility Anti-Terrorism Standards
2007	DHS	1652-AA41	Transportation Worker Identification Credential (TWIC) Implementation in the Maritime Sector
2007	EPA	2050-AG23	Oil Pollution Prevention; Spill Prevention, Control, and Countermeasure (SPCC) Requirements—Amendments
2007	EPA	2060-AK70	Control of Hazardous Air Pollutants from Mobile Sources
2006	EPA	2040-AD38	National Primary Drinking Water Regulations: Stage 2 Disinfection Byproducts Rule
2006	EPA	2060-AI44	Review of the National Ambient Air Quality Standards (NAAQS) for Particulate Matter
2006	EPA	2060-AM82	Standards of Performance for Stationary Compression Ignition Internal Combustion Engines
2006	DOT	2120-AI51	Congestion and Delay Reduction at Chicago O'Hare International Airport
2005	EPA	2040-AD37	National Primary Drinking Water Regulations: Long Term 2 Enhanced Surface Water Treatment Rule
2005	DOT	2126-AA90	Hours of Service of Drivers