

THE NEAR-TERM OUTLOOK FOR ENERGY AND COMMODITY MARKETS

HEARING BEFORE THE COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE ONE HUNDRED FOURTEENTH CONGRESS SECOND SESSION

JANUARY 19, 2016



Printed for the use of the
Committee on Energy and Natural Resources

Available via the World Wide Web: <http://fdsys.gov>

U.S. GOVERNMENT PUBLISHING OFFICE

98-966

WASHINGTON : 2017

For sale by the Superintendent of Documents, U.S. Government Publishing Office
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THE NEAR-TERM OUTLOOK FOR ENERGY AND COMMODITY MARKETS

TUESDAY, JANUARY 19, 2016

U.S. SENATE,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The Committee met, pursuant to notice, at 10:10 a.m. in Room SD-366, Dirksen Senate Office Building, Hon. Lisa Murkowski, Chairman of the Committee, presiding.

OPENING STATEMENT OF HON. LISA MURKOWSKI, U.S. SENATOR FROM ALASKA

The CHAIRMAN. Good morning. We will call to order this hearing before the Committee on Natural Resources.

Gentlemen, thank you for joining us this morning.

This is the first hearing that the Energy Committee has had in 2016, and I think it is rather auspicious that today we are going to be conducting oversight to examine the near-term outlook for energy and commodity markets. I think everybody is interested in what you have to say, the predictions, the forecasts. Hopefully your crystal balls are clear and sharp this morning.

It is an issue that is not only interesting but clearly consequential in so many different ways as we look to the outlook for not only the energy, but the mineral markets as well.

There are few commodities that are more foundational to the health of our economy than energy and minerals. Most Americans are certainly familiar with gasoline prices and their electricity bills, but I would submit that it is our responsibility as Senators on this Committee to do our best to understand the complex interplay of our nation's energy mix and the influences that drive key energy and resource indicators. Low oil prices, for example, lead to lower gasoline prices. Americans are certainly enjoying that.

But what is the knock on effect with respect to our natural gas prices? As fossil fuel prices fall, how does that affect the competitiveness for renewables, as well as nuclear power? Also what is the impact on jobs, on consumer spending and so on? There is just so much that is, again, interrelated and the complexities are such that we require experts to come and give us a little bit of a forecast as to how it all plays out.

I am reminded, however, that as we see things like lower oil prices in the lower 48, they are not necessarily reflected evenly across the United States. I was home in Nome, Alaska, about ten days or so ago. The prices up in Nome are in the mid-\$5 range. Down in Unalakleet, where I was the following day, it was about

\$5.40 a gallon. They are looking with some envy at the fact that in the lower 48 we are looking at gas prices at the pump just above \$2.00. Sometimes things do not work to the benefit of all evenly and I think that is something that we keep a particular eye on in Alaska.

We did some good work on the Committee here last year in 2015, and I think within the Senate itself. We saw the return of regular order in the Senate a little bit.

In energy policy we laid some foundations to modernize our strategic petroleum reserve, we lifted the ban on oil exports, and then more specific to where we are right now, we passed on an 18 to 4 bipartisan vote, the Energy Policy Modernization Act that moved out of this Committee.

I am working to ensure that bill gets to the floor, hopefully as soon as possible. I think it is fitting, therefore, that we hold this hearing on the broad energy outlook shortly before the full Senate might turn to our broader energy bill. It is my hope we will gather critical, current information this morning to inform our thinking before we head to the floor to debate S. 2012.

So again, I thank all the witnesses for joining us this morning. We have some familiar faces, Mr. Sieminski, who has ably led the Energy Information Administration (EIA). We have some newcomers as well, and we welcome you. We are fortunate that there are reams of data from government and neutral sources to help us deepen our understanding of the energy markets, and I look forward to hearing from you all.

With that I will turn to my Ranking Member, Senator Cantwell, for your comments this morning.

STATEMENT OF HON. MARIA CANTWELL, U.S. SENATOR FROM WASHINGTON

Senator CANTWELL. Thank you, Madam Chair, and thank you for holding this important hearing to examine the near-term outlook for energy markets. I thank the witnesses for joining us here today on a very important and timely discussion ahead of a potential floor debate on the bipartisan energy bill.

Energy markets have been changing rapidly in the last year and I am sure we are going to hear a lot about that, but I want to emphasize a few things. Utility scale wind capacity has grown by 677 percent from less than nine gigawatts to nearly 70 gigawatts in the last ten years. In part, the successes were enabled by an all-time low reduction in the cost of wind power; the rates for wind power purchase agreements have fallen seven cents a kilowatt-hour in 2009 to two cents a kilowatt-hour recently. That is a 71 percent drop.

These trends are prevalent all across the United States. Utility-scale wind power is deployed across 39 states, and in nine states, wind exceeds ten percent of the total in-state electricity generation. And it is not just wind. Solar photovoltaic technology has rapidly emerged as a mainstream technology over the last few years. Utility-scale PV solar has grown to more than ten gigawatts in 2015, and distributed PV systems installed on customer and business rooftops have seen the same level of growth. Now there are more than 80,000 distributed PV systems installed. This is possible be-

cause of a dramatic decline in the price of PV systems, down 59 percent, over the last six years.

But interest in renewable energy has not just been from electric utilities and customers. In 2015, there was a record-breaking year for corporations such as Amazon, Microsoft, Google, Walmart, who purchased large-scale wind and solar energy. These corporations signed roughly three gigawatts of power purchase agreements for large-scale renewable energy last year. This is more than double the amount signed in 2014.

These trends have also been benefiting my home state. Washington's wind industry is seventh in the nation for installed wind capacity and ranks 15th in the country for solar power capacity per person, 25th in the nation for total solar capacity. Recent policy changes will accelerate these trends creating more jobs, reducing carbon pollution and saving consumers money.

Why the sudden drop in cost? In part because of policy in 2015 in the addition of new policies that will build upon the success of previous support for renewable energy. For instance, in August 2015 the EPA finalized the Clean Power Plan Rule which will reduce carbon pollution from power plants and drive a more aggressive transition to renewable energy. Last December more than 190 nations reached a historic accord to address climate change committing nearly every country to lower carbon pollution and keep global temperatures from rising more than two degrees Celsius.

These domestic and global commitments to reducing carbon pollution will create new global market opportunities and export opportunities for the U.S. and our technologies. In fact, the International Energy Agency estimates that \$4 trillion in renewable energy investments and about \$8 trillion in energy efficiency investments will be made across the world in the next 15 years.

Lastly, at the end of the last year, the Omnibus spending bill included long-term extensions for clean energy tax credits. That will also be sending a signal. According to Bloomberg New Energy Finance, as I am sure we will hear shortly, it is estimated that this will result in 76 percent more wind energy and 44 percent more solar energy than if these policies had not been extended.

All these policies continue to accelerate the trends of clean energy development, reducing carbon pollution, saving consumers money, and creating jobs. This is a big factor for us to consider here. There are job creation activities going on here.

A report from the Solar Foundation found that the U.S. solar industry employed more than 200,000 Americans in 2015 with 20 percent growth in the solar industry employment.

[The information referred to follows:]

The Solar Foundation's National Solar Jobs Census 2015 Finds that U.S. Solar Workforce Grew by More Than 20% for the Third Consecutive Year

More than 35,000 solar jobs added in 2015, bringing U.S. solar workforce total to nearly 209,000; an increase of 123% since 2010.

WASHINGTON, DC – Jan. 12, 2016 – The Solar Foundation (TSF), an independent nonprofit solar research and education organization, today released its sixth annual *National Solar Jobs Census*. The new *Census 2015* found that the U.S. solar industry employed **208,859** Americans in 2015, a figure that includes the addition of 35,052 solar workers over the previous year, representing 20.2 percent growth in solar industry employment in the 12 months preceding November 2015. Solar employment grew nearly 12 times faster than the national employment growth rate of 1.7 percent during the same period.

“The solar industry has once again proven to be a powerful engine of economic growth and job creation,” said **Andrea Luecke, President and Executive Director of The Solar Foundation**. “Employment in solar has grown an extraordinary 123 percent since 2010, adding approximately 115,000 well-paying jobs. Our *Census* findings show that one out of every 83 new jobs created in the U.S. over the last 12 months was in the solar industry – 1.2% of all new jobs. The Solar Foundation is proud to play a vital role in delivering comprehensive solar jobs information to key decision makers about the technology’s tremendous contributions to the U.S. economy.”

The solar workforce is larger than some well-established fossil fuel generation sectors, such as the oil and gas extraction industry, which shed 13,800 jobs in 2015 and now employs 187,200 people. The oil and gas pipeline construction industry, which employs 129,500 workers, lost 9,500 jobs (U.S. BLS) during the same

1/20/2016 PRESS RELEASE: The Solar Foundation's National Solar Jobs Census 2015 Finds that U.S. Solar Workforce Grew by More Than 20% for the Third Co...

period. The solar industry is already three times larger than the coal-mining industry, which employs 67,929 people (JobsEQ 2015Q3). Solar employers surveyed expect to add more than 30,000 jobs over the next 12 months. The expected increase of 14.7% would bring the count of U.S. solar workers to 239,625 by the end of 2016.

Respected U.S. leaders and companies lauded the *National Solar Job Census 2015* findings.

“The U.S. solar power industry continues to grow and create jobs, providing further evidence that promoting economic growth and fighting climate change can go hand-in-hand. The *Solar Jobs Census* helps fuel this progress by offering policymakers and investors the clean energy data they need to make informed decisions,” said **Michael R. Bloomberg, founder of Bloomberg L.P., philanthropist, United Nations Secretary General's Special Envoy for Cities & Climate Change, and three-term Mayor of New York City.**

“The continued growth and vitality of the solar industry is welcome news, especially after world leaders convened in Paris and signed an historic agreement recognizing the importance of climate change and of renewable energy as a way to help address it,” said **Rick Needham, Director, Energy and Sustainability at Google.** “As the largest corporate procurer of renewable power in the world and one of the largest corporate investors in both utility scale and residential solar, we’re doing our part to support solar not only because it provides clean, renewable power but also because it makes great business sense. And with the launch and recent expansion of our Project Sunroof, we’re helping our users explore whether solar makes sense for them and provides a pathway for cleaner power, economic savings, and more jobs.”

“Solar is surging. Renewable energy deployment is on track to transform our world, helping to lessen our reliance on coal and other polluting fossil fuels,” said **Board of Los Angeles County Chair and former U.S. Labor Secretary Hilda L. Solis.** “Solar’s growth will continue to be robust in coming years. With wider solar adoption, thousands more high-quality jobs will be added to the economy that help propel us forward and advance our economic and environmental goals.”

“As the *Census* underscores, solar is providing a tremendous boost to our economy while meeting public demand for clean, affordable energy,” said **Andrew Birch, CEO of Sungevity,** the largest privately held

1/20/2016 PRESS RELEASE: The Solar Foundation's National Solar Jobs Census 2015 Finds that U.S. Solar Workforce Grew by More Than 20% for the Third Co...

solar installer in the U.S. “We’re extremely proud to be one the fastest growing solar companies in the U.S. ... and part of an industry that’s creating hundreds of thousands of high-quality jobs.”

“Americans want good-paying jobs, and solar jobs are growing 12 times faster than the rest of the economy,” said **former Michigan Governor Jennifer Granholm**. “Our citizens are making and installing those solar panels, and with the right policies, the U.S. can create hundreds of thousands more solar jobs here at home. What more needs to be said?”

The Solar Foundation and BW Research Partnership conducted the *National Solar Jobs Census 2015*. The report includes data collected from more than 19,000 U.S. businesses. The results from the *Census* are based on rigorous survey efforts that include 287,962 telephone calls and over 44,220 emails to known and potential energy establishments across the United States, resulting in a total of 2,350 full completions for solar establishments in the U.S. The sampling rigor in the known and unknown universes provides a margin of error for establishment counts at $\pm 0.85\%$ and employment at $\pm 1.99\%$ at a 95% confidence interval.

“*Census 2015* shows that solar company growth has been remarkably consistent over the last five years, despite an uneven jobs recovery in the U.S. over the same period,” said **Philip Jordan, Vice President at BW Research Partnership**. “Indications point to this sustained, upward trajectory continuing apace in the months and years ahead as the U.S. transitions to a clean energy economy.”

The full *National Solar Jobs Census 2015* report is now available at<http://TSFcensus.org>.

A new and highly interactive map featuring *Solar Jobs Census* data broken out by state, county, and legislative districts will be available at <http://SolarStates.org> in mid-February.

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About The Solar Foundation:

The Solar Foundation® (TSF) is an independent 501(c)(3) nonprofit whose mission is to increase understanding of solar energy through strategic research and education that transform markets. Since 2010, TSF has published its annual *National Solar Jobs Census*, which established the first credible solar jobs base

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line for the U.S. TSF is considered the premier research organization on the solar labor workforce, employer trends, and the economic impacts of solar and advises many organizations on the topic. TSF is also a leading provider of educational materials on the economic impacts of solar for local governments through its work with the U.S. Department of Energy. In addition, TSF chairs the National Solar Schools Consortium, a group of stakeholders seeking to make solar a larger part of the national K-12 system. More at TheSolarFoundation.org

About BW Research Partnership:

BW Research is widely regarded as the national leader in labor market analysis for emerging industries and clean energy technologies. BW Research provides high quality data and keen insight into economic and workforce issues related to renewable energy, energy efficiency, transportation, recycling, water, waste, and wastewater management, and other environmental fields. The principals of the firm are committed to providing research and analysis for data-driven decision-making. More at bwresearch.com

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For perspective, the solar industry grew 12 times faster than the national employment growth rate during this same time period, and the solar work force is now larger than the more well-established fossil fuel generation sectors such as the oil and gas extraction industry.

The U.S. wind industry has had similar job growth trends, supporting over 70,000 well-paying jobs.

It is also important to talk about the consumer in this equation. Renewable energy policies not only create jobs, but they help save money for consumers and provide consumers with more choices.

In a new study by the National Renewable Energy Laboratory at Lawrence Berkeley National Laboratory, renewable portfolio standards help to lower prices saving consumers up to \$1.2 billion from lower electricity prices and \$3.7 billion from reduced natural gas prices.

Recent low oil and natural gas prices have also resulted in savings for consumers. For example, the AAA estimates that Americans saved \$115 billion on gasoline in 2015 compared to 2014, which was an average of about \$550 per driver.

However, these fossil fuel commodities are still susceptible to price swings, and I am sure we are going to hear about that today. Less than two years ago the oil prices were over \$100 a barrel and EIA's short-term energy outlook states that, "Oil prices could continue to experience periods of heightened volatility" over the next two years. In contrast, renewable technologies, which use wind and solar, are not as susceptible to these price volatilities. Consumers should have choices and should not face roadblocks to being able to implement these choices.

We will continue to support those policies that give homeowners and businesses the freedom to generate their own energy. Whether you are an environmentalist or a Member of the Tea Party, supporting distributed generation and making sure consumers get access to choose their own energy distribution or storage methods is something, I think, we will continue to be talking about.

Again, thank you Madam Chair for holding this important hearing, and I hope that we will hear a lot from our witnesses today about how and what we can expect in the next few years.

[The written statement of Senator Cantwell follows:]

Senator Cantwell Statement on Energy-Related Job Estimates

The Bureau of Labor Statistics produced its green jobs report in March 2013. It estimated that "employment associated with the production of green goods and services" exceeded 3.4 million in 2011.

As for the oil and gas industry itself, a July 2013 report was done by PricewaterhouseCoopers for the American Petroleum Institute, a trade association for the oil and natural gas industry. The report said there were 2.59 million jobs in the oil and natural gas industry in 2011. PricewaterhouseCoopers said it utilized data from the Bureau of Labor Statistics, the U.S. Bureau of Economic Analysis and the U.S. Census Bureau for its study.

From the estimates for 2011, the federal government says there were 3.4 million green jobs, while a national oil and gas trade group says there were 2.59 million oil and gas jobs.

The CHAIRMAN. Thank you.

With that we will turn to our panel of witnesses. It will be led off by Mr. Adam Sieminski, who is the Administrator for U.S. Energy Information Administration, the EIA. He will be followed by Mr. Antoine Halff, the Program Director for the Global Oil Markets for the Center on Global Energy Policy located at Columbia University. We also have Mr. James Lucier, who is the Managing Director for Capital Alpha Partners. We also have Mr. Ethan Zindler, who has joined the Committee here today as Head of the Americas, Bloomberg New Energy Finance. Rounding things out is Mr. Daniel McGroarty, who is the Principal at Carmot Strategic Group.

With that, Mr. Sieminski, if you would begin with the panel?

I know you have a lot to say, so we will probably have to go over our allocated five minutes. We are good with that because there is a fair amount of information that I think needs to be imparted.

STATEMENT OF HON. ADAM SIEMINSKI, ADMINISTRATOR, U.S. ENERGY INFORMATION ADMINISTRATION, U.S. DEPARTMENT OF ENERGY

Mr. SIEMINSKI. Maybe just a couple of minutes, Senator. [Laughter.]

The CHAIRMAN. Well, we appreciate what you will give to us and know that we will also have opportunities for expansion when we come to the Q and A.

If you would please start off.

Mr. SIEMINSKI. Thank you, Chairman Murkowski, Ranking Member Cantwell, Senators Cassidy and Hoeven. I really appreciate the opportunity to provide testimony today on the U.S. energy outlook.

The Energy Information Administration is a statistical and analytical agency within the Department of Energy, but by law EIA's data analysis and forecasts are independent of approval by any other Federal office or employee. Therefore, my views should not be construed as representing those of the Department of Energy or any other Federal agency.

Major changes affecting energy markets have occurred over the past year in the areas of global commodity prices, energy technologies and U.S. energy and environmental policies. EIA's Annual Energy Outlook for 2016, which will be published by mid-year, will include these changes.

What I'd like to do now is talk just a little bit about last year and then we'll talk about the forecast.

Crude oil ended 2015 with both Brent and WTI below \$40 a barrel, the lowest level since early 2009. The decline has continued with today's WTI price trading just under \$30 a barrel. With the fall in prices U.S. onshore crude oil production began to decline in early 2015 but still averaged 9.4 million barrels a day and that was eight percent higher than 2014.

Natural gas spot prices at Henry Hub in Louisiana averaged \$2.63 per million BTU in 2015 and that was 40 percent below the 2014 average; however, the rigs that continued drilling were highly productive and total dry natural gas production in 2015 reached an estimated 74 and a half billion cubic feet per day, almost six percent higher than 2014.

In April of '15 natural gas-fired electricity generation surpassed that of coal-fired generation on a monthly basis for the first time in history and did so for much of the rest of the year. That and lower exports led coal production in 2015 to fall below 900 million short tons, the lowest level since the mid-1980's.

Commodity prices, weather and investment in renewable capacity drove changes in electricity. The wholesale price of electricity set by natural gas generators fell between 27 to 37 percent at major trading hubs across the nation. Nuclear generation through October of '15 was the highest since 2010 due to low levels of outages. They were the lowest on record of about three percent of the summer capacity.

Hydroelectricity accounted for nearly six percent of total generation through October despite lower than normal water and snow pack levels in several regions. Wind provided four percent of the number.

Net generation from distributed solar PV systems increased 28 percent and utility scale solar photovoltaic generation increased by half over the first ten months of 2015 based on EIA's new monthly estimates of capacity and generation from small scale distributed solar that we are now publishing by both sector and state.

Now I'm going to turn to the short term energy outlook which provides a monthly forecast through 2017.

Crude oil and refined product prices in 2016 are forecast to be lower than in 2015 with Brent crude back up to about \$40 a barrel by the end of '16 and \$50 a barrel in 2017 with WTI averaging \$2 to \$3 a barrel lower than Brent.

A word of caution is advisable. The current values in the futures and options markets suggest that market participants see very high uncertainty in the price outlook. This is similar to what Senator Cantwell said, and the risk is both on the upside and the downside. The retail price of regular gasoline is forecast to average just a little over \$2 a gallon in 2016 and \$2.21 in 2017. And that's down from \$2.43 last year and down from \$3.36 in 2014, so a big drop in gasoline prices.

U.S. crude oil production is expected to continue to decline through 2016 and through most of 2017. So this is very different than two years ago when production was climbing and climbing rapidly. The global oil market becomes more balanced because of these declines in 2017. Non-OPEC production is estimated to fall by 600,000 barrels a day in 2016, about two thirds of that is driven by lower production in the United States.

Outside of the U.S. non-OPEC production declines are relatively small because of past investments and project commitments made when oil prices were higher. Canada and Brazil are good examples of that situation. EIA forecasts a half a million barrel a day increase in OPEC crude oil production in 2016 and about 0.6 million barrels a day in 2017 with Iran, again, accounting for most of the increase at 300,000 barrels a day in 2016 and a half a million barrels a day in 2017. There were developments there over the week-end with the sanctions finally being removed. EIA's forecast assumed that sanctions targeting Iran's oil sector would be lifted and that is the case.

EIA's forecast for Henry Hub spot prices to average \$2.65 a million BTU in 2016 and \$3.22 in 2017. Current levels are near \$2.00. That would be a fairly big increase but it reflects consumption growth, mainly in the industrial sector, fertilizers and chemicals, for example. And EIA expects a small decline in the power sector as natural gas prices rise and renewables hydro, wind, and solar, increase.

EIA projects production growth will be slow in 2017 as prices rise with more demand from industrial users and exports, and the exports are expected to grow quite a bit. Both pipeline to Mexico and liquefied natural gas tanker shipments with the startup of Cheniere Sabine Pass facility later in the spring.

Coal consumption in the power sector forecast remains unchanged in 2016 and declines slightly in 2017 while the forecast of higher natural gas prices helps to support coal generation. Expected increases in electricity from renewables and nuclear reduce the need for coal generation. With slower growth in world coal demand and lower international coal prices also expected, U.S. coal production is forecast to decline by 38 million short tons in 2016 and by an additional nine million tons in '17.

The change in the mix of electric generating units that supply the United States is expected to continue with a declining generation share from fossil fuels offset by the growth in the role of renewable resources as shown in Table 1 in my full written statement.

Madam Chairman, this concludes my testimony, and I would be happy to answer questions later.

[The prepared statement of Mr. Sieminski follows:]

STATEMENT OF ADAM SIEMINSKI
ADMINISTRATOR
U.S. ENERGY INFORMATION ADMINISTRATION
U.S. DEPARTMENT OF ENERGY
BEFORE THE
COMMITTEE ON ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE
JANUARY 19, 2016

Chairman Murkowski, Ranking Member Cantwell and Members of the Committee, I appreciate the opportunity to appear before you today to provide testimony on the U.S. energy outlook.

The U.S. Energy Information Administration (EIA) is the statistical and analytical agency within the U.S. Department of Energy. EIA collects, analyzes, and disseminates independent and impartial energy information to promote sound policymaking, efficient markets, and public understanding regarding energy and its interaction with the economy and the environment. EIA is the Nation's primary source of energy information and, by law, its data, analyses, and forecasts are independent of approval by any other officer or employee of the United States Government. The views expressed in our reports, therefore, should not be construed as representing those of the Department of Energy or other federal agencies.

The energy data and projections that I will discuss today are widely used by government agencies, the private sector, and academia as a starting point for their own energy analyses. For the U.S. energy sector, EIA prepares both short-term energy outlooks, examining monthly trends over the next one to two years, and long-term outlooks, with annual projections over the next 20-to-25 years. I will summarize some key findings from our January Short-Term Energy Outlook (STEO), as well as some of EIA's recently published 2015 data reviews that provide context for the outlook. The Annual Energy Outlook 2016 (AEO2016), which takes a longer-term perspective, will be released in late spring.

Developments in 2015

During the past year there were major changes in global commodity prices, energy technologies and U.S. energy and environmental policies, including the statutory removal of longstanding restrictions on U.S. crude oil exports, issuance of the final Clean Power Plan rule, and extensions of tax credits for wind and solar generation technologies.

Crude oil, natural gas, and coal commodity prices started 2015 relatively low and ended the year even lower.

Crude Oil: Crude oil prices ended 2015 with North Sea Brent and West Texas Intermediate (WTI) below \$40 per barrel (b), the lowest level since early 2009. (Figure 1) Price declines have continued into the first two weeks of 2016 with prices near \$30/b on January 12. U.S. crude oil production began to decline in the second quarter of 2015 led by reductions in Lower 48 onshore production. Even with the recent price decline, U.S. production averaged an estimated 9.4 million barrels per day (b/d) in 2015, an 8% increase over 2014 and the highest rate since 1972.

EIA estimates that total Organization of the Petroleum Exporting Countries (OPEC) crude oil and other liquids production increased 3% to 38.3 million b/d in 2015, led by production growth in Iraq. Global oversupply relative to demand lead to increases in inventories in each quarter of 2015, with a net global inventory build of 1.9 million barrels per day, the highest rate since at least 1994. (Figure 2)

Natural Gas: Natural gas spot prices in 2015 at the Henry Hub in Louisiana averaged \$2.63 per million British thermal unit (MMBtu), \$1.76/MMBtu below the 2014 average. (Figure 3) Spot

prices fell throughout 2015, as production and storage inventories hit record levels and fourth-quarter temperatures were much warmer than normal. Although the natural gas-directed rig count was cut in half over the year, the remaining rigs were highly productive with continuing gains in drilling efficiency. As a result, total dry natural gas production in 2015 reached an estimated 74.5 billion cubic feet per day (Bcf/d), 5.6% higher than in 2014. (Figure 4)

Coal: Coal production in 2015 is estimated to have fallen below 900 million short tons (MMst), 11% lower than in 2014 and the lowest level since 1986. (Figure 5) Regionally, production from the Appalachian Basin experienced the largest percentage decline in production. Low natural gas prices, slower international coal demand growth, and environmental regulations have contributed to reduced demand for coal. In April 2015, natural gas-fired electricity generation surpassed that of coal-fired generation on a monthly basis for the first time in history, and it did so again in each of the months from July through at least October, the latest monthly data available. The most recent *Short-Term Energy Outlook* estimates 2015 power sector coal consumption at about 754 MMst, the lowest level since the late 1980s.

Commodity prices, weather and investment drive changes in electricity

Wholesale electricity prices at major trading hubs on a monthly average basis for on-peak hours were down 27%-37% across the nation in 2015 compared with 2014. Lower natural gas prices have been a key driver of lower wholesale electricity prices because natural gas-fired generation sets the marginal price in many regional markets. Capacity factors, which measure actual generation as a percent of a potential maximum, averaged 57% for combined-cycle natural gas

plants through October, well above the 49% average in each of the two previous January-October periods.

Nuclear generation was the highest since 2010 (through October) as low levels of outages led to high capacity factors. Nuclear outages were less than 3% of capacity this summer and dropped to nearly zero during four days in August, the lowest levels on record.

Among renewable sources, hydroelectricity continued to provide the most generation in 2015, accounting for 6% of the nation's total generation through October, despite lower-than-normal water and snowpack levels in several regions with significant hydro resources. Through October, generation from wind and solar plants provided 4% and 1%, respectively, of total generation. Net generation from distributed solar photovoltaic (PV) systems increased 28% and utility-scale solar PV generation increased 50% over the first 10 months of 2015 compared to the same period in 2014. Beginning with the November Electric Power Monthly, EIA now reports monthly estimates of capacity and generation from small-scale distributed solar PV by sector and state alongside data for utility-scale generation. Previously, EIA had provided only annual estimates at the national level for small-scale distributed solar PV.

Nearly all new utility-scale capacity of 1 megawatt (MW) or greater that was added in 2015 consisted of natural gas, wind, and solar units. Coal units accounted for most generator retirements during the year—more than 11,000 MW of coal-fired capacity retired through October 2015, with an additional 2,600 MW estimated to have retired by December.

EIA Short-Term Energy Outlook (STEO)

EIA's STEO provides a monthly forecast covering the current and upcoming calendar years.

The Outlook published January 12, 2016, is the first to include forecasts for 2017.

Crude oil and refined product prices in 2016 are forecast to be lower than in 2015

North Sea Brent crude oil prices averaged \$52/b in 2015 as growth in global liquids inventories put downward pressure on Brent prices. By December the price was \$38/b, a \$6/b decrease from November, and the lowest monthly average price since June 2004. EIA forecasts the average Brent crude oil prices at \$40/b in 2016 and \$50/b in 2017. EIA forecasts West Texas Intermediate (WTI) crude averages \$2/b lower than Brent in 2016 and \$3/b lower in 2017. However, the current values of futures and options contracts continue to suggest high uncertainty in the price outlook (Figure 6). For example, EIA's forecast for the average WTI price in April 2016 of \$37/b should be considered in the context of recent futures and options contract values for April 2016 delivery suggesting that the market expects WTI prices to range from \$25/b to \$56/b (at the 95% confidence interval).

Lower gasoline prices are expected to save average household \$280 in 2016 compared with 2015

The price of U.S. retail regular gasoline is forecast to average \$2.03/gallon (gal) in 2016 and \$2.21/gal in 2017, compared with \$2.43/gal in 2015. In December, average retail regular gasoline prices were \$2.04/gal, a decrease of 12 cents/gal from November and 51 cents/gal lower than in December 2014. EIA expects monthly retail prices of U.S. regular gasoline to reach a seven-year low of \$1.90/gal in February 2016, before rising during the spring.

U.S. crude oil production is expected to decline through 2016 and most of 2017

U.S. crude oil production in December fell 80,000 b/d from the November 2015 level, and declines are expected to continue for much of the next two years. Crude oil production averaged an estimated 9.4 million b/d in 2015, and is forecast to average 8.7 million b/d in 2016 and 8.5 million b/d in 2017.

EIA estimates that global oil inventories increased by about 1.9 million b/d in 2015, marking the second consecutive year of inventory builds. The excess of supply over demand has contributed to oil prices reaching the lowest monthly average level since mid-2004. Inventories are forecast to continue rising in 2016, before the global oil market becomes more balanced in 2017. (Figure 2) The first draw on global oil inventories in 15 consecutive quarters is expected in the third quarter of 2017.

EIA estimates global consumption of petroleum and other liquids grew by 1.4 million b/d in 2015, averaging 93.8 million b/d for the year. Forecast real gross domestic product (GDP) for the world, weighted by oil consumption, grew by an estimated 2.4% in 2015 and is expected to increase at the rates of 2.7% in 2016 and by 3.2% in 2017. EIA expects global consumption of petroleum and other liquids to continue growing by 1.4 million b/d in both 2016 and 2017.

Non-OPEC production is estimated to decline by 0.6 million b/d in 2016, the first decline since 2008, and at a slower rate in 2017. The outlook for non-OPEC production is driven largely by changes in U.S. tight oil production, which is characterized by high decline rates and relatively short investment horizons that make it among the most price sensitive production globally. As

low oil prices contribute to drilling rig counts falling below levels required to sustain current production levels, forecast total U.S. liquids production declines by 0.4 million b/d in 2016 and remains relatively flat in 2017.

Outside of the United States, forecast non-OPEC production declines by 0.2 million b/d in 2016 and by 0.1 million b/d in 2017. Despite low crude oil prices, production declines are relatively minor because of past investments in Canada and Brazil, in particular, where project commitments were made when oil prices were higher. Production in Canada is expected to increase by 50,000 b/d in both 2016 and 2017, as a number of oil sands projects are scheduled to come online by the end of 2016.

OPEC crude oil production averaged nearly 31.6 million b/d in 2015 (including recently rejoined Indonesia), an increase of 0.9 million b/d from 2014. Iraq led the OPEC increase as its production rose by 0.7 million b/d in 2015, and Saudi Arabia boosted production by 0.3 million b/d in 2015.

EIA forecasts a 0.5 million b/d increase in OPEC crude oil production in 2016. In developing the latest STEO, EIA assumed that sanctions targeting Iran's oil sector would be lifted in the first quarter of 2016. Forecast OPEC crude oil production is expected to increase in 2017 by 0.6 million b/d, with Iran again accounting for most of the increase. Iran's crude oil production is forecast to grow by an average of about 0.3 million b/d in 2016 and by 0.5 million b/d in 2017.

OPEC surplus crude oil production capacity, which averaged 1.6 million b/d in 2015, is expected to increase to 2.0 million b/d in 2016 and then average 1.9 million b/d 2017. Surplus capacity below 2.5 million b/d has often been viewed as an indication of tight oil market conditions. However, given the current excess of supply over demand and high current and forecast levels of global oil inventories, the projected low level of surplus capacity is less significant.

U.S. natural gas demand is expected to increase as supply growth moderates, resulting in prices rising from their end-of-2015 level

EIA forecasts Henry Hub spot prices to average \$2.65/MMBtu in 2016, close to the 2015 average of \$2.63/MMBtu, and \$3.22/MMBtu in 2017. While average price levels in 2015 and 2016 are expected to be similar, 2015 was marked by generally decreasing prices, and Henry Hub prices began 2016 near \$2/MMBtu, a level from which they are forecast to rise through much of the year. The forecast price increase reflects consumption growth, mainly from the industrial sector. EIA expects production growth will be relatively flat in 2016, partly in response to lower prices and declining rig activity. With higher prices in 2017, and as new consumption and more export capacity comes online, EIA projects production will pick up slightly.

EIA's forecast of U.S. total natural gas consumption averages 76.6 billion cubic feet/day (Bcf/d) in 2016 and 77.2 Bcf/d in 2017, compared with 75.5 Bcf/d in 2015. Increases in industrial sector consumption drive total consumption growth in 2016 and 2017. Industrial sector consumption of natural gas increases by 3.5% in 2016 and by 2.5% in 2017, as new projects in the fertilizer and chemicals sectors come online. For power generation, EIA expects a 0.1 Bcf/d (0.3%) decline in

consumption in 2016 and a 1.4% decrease in 2017, as natural gas prices rise and hydroelectric generation in the West and wind and solar generation increase. Natural gas consumption in the residential and commercial sectors is projected to increase in 2016 and 2017, reflecting slightly higher heating demand in those years.

Total marketed production of natural gas is estimated to have averaged 79.1 Bcf/d over 2015, 5.7% higher than 2014. EIA projects growth will slow to 0.7% in 2016, as low natural gas prices and declining rig activity begin to affect production. By 2017, however, forecast production growth increases to 1.8%, as prices rise and more demand comes from industrial sectors and exports.

U.S. natural gas exports, by both pipeline and liquefied natural gas (LNG) tanker shipments, are expected to increase through 2017. Although overall domestic demand growth levels off, production remains high, reducing demand for natural gas imports from Canada while supporting growing exports to Mexico. Growing demand from Mexico's electric power sector coupled with flat natural gas production in Mexico creates a growth opportunity for U.S. pipeline gas. With the startup of Cheniere's Sabine Pass liquefaction plant in early 2016 and subsequent increases in liquefaction capacity, EIA projects LNG gross exports will increase to an average of 0.7 Bcf/d in 2016 and 1.4 Bcf/d in 2017.

Natural gas working inventories were 3,475 billion cubic feet (Bcf) on January 8, 20% higher than during the same week last year and 16% higher than the previous five-year average (2011-

15) for the week. EIA forecasts inventories will end the winter heating season (March 31) at 2,043 Bcf, 38% above the level at the same time last year.

Coal demand expected to remain weak

EIA estimates that coal consumption decreased by 11% in 2015, mainly as a result of an 11% drop in electric power sector consumption. Higher forecast natural gas prices in 2016 and 2017 are expected to contribute to higher utilization rates among the remaining coal-fired power plants. This higher utilization rate offsets the effect of lower consumption from coal-plant retirements. Coal consumption in the electric power sector is forecast to remain relatively unchanged in 2016. In 2017, increases in electricity generation from renewables and nuclear are forecast to contribute to a 1% decline in electric power sector coal consumption.

Slower growth in world coal demand and lower international coal prices have contributed to a decline in U.S. coal exports. Lower mining costs, cheaper transportation costs, and favorable exchange rates will continue to provide an advantage to mines in other major coal-exporting countries compared with U.S. producers over the next few years. EIA estimates U.S. coal exports decreased by 20 MMst (21%) in 2015. The current global coal market trends are expected to continue, and coal exports are forecast to decline by an additional 9 MMst (12%) in 2016 and by 2 MMst (4%) in 2017.

Forecast U.S. coal production is projected to fall by 38 MMst (4%) in 2016 and by an additional 9 MMst (1%) in 2017.

The electricity generation mix is expected to continue changing

The mix of generating units that supply electricity in the United States has been undergoing a significant transformation. (Table 1) Many older coal plants are being retired as the industry adapts to sustained low costs of competing natural gas generating units, growing renewable generation, and the effects of environmental regulations. EIA estimates that at least 14 gigawatts (GW) of coal-fired capacity were retired during 2015, equal to nearly 5% of the operable coal capacity existing at the end of 2014. Power plant operators have reported to EIA that they plan to retire at least 10.7 GW of additional coal capacity during 2016 and 2017.

A decline in power generation from fossil fuels in the forecast period is offset by an increase from renewable sources. The share of generation from natural gas falls from 33% in 2015 to 31% in 2017, as natural gas prices rise, hydroelectric generation in the West increases, and other renewable generation increases. Coal's share of generation falls from 34% in 2015 to 33% in 2017. For renewables, the forecast share of total generation supplied by hydropower rises from 6% in 2015 to 7% in 2017, and the forecast share for other renewables increases from 7% in 2015 to 9% in 2017.

The U.S. retail price of electricity in the residential sector is projected to average 12.7 cents per kilowatthour (kWh) in 2016, unchanged from 2015. The U.S. retail price in 2017 is expected to increase 3%.

Conclusion

This concludes my testimony, Madam Chairman and Members of the Committee. I would be happy to answer any questions you may have.

Figure 1: Brent and West Texas Intermediate (WTI) spot prices

Daily crude oil spot prices, 2009-16
dollars per barrel

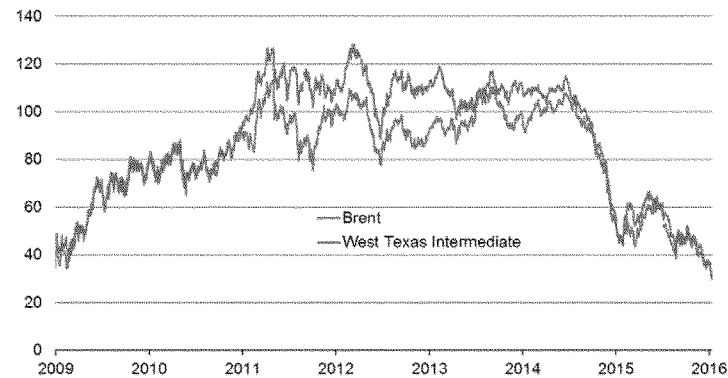


Figure 2: Oil supply and demand begin to rebalance in 2017

World Liquid Fuels Production and Consumption Balance
million barrels per day

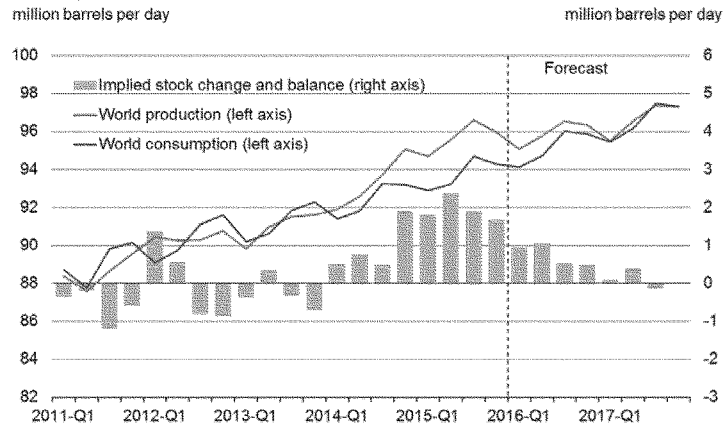
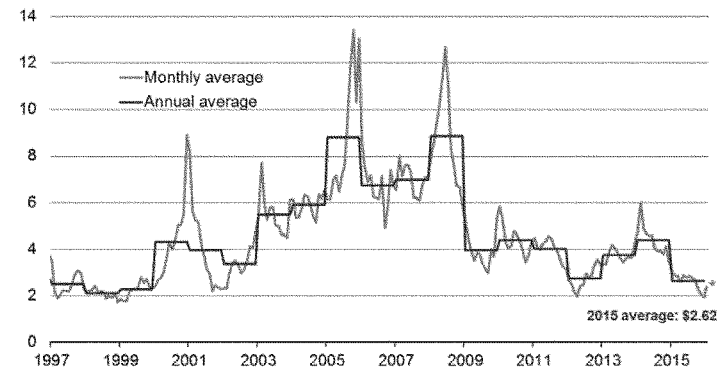


Figure 3: Average annual natural gas spot price in 2015 was at lowest level since 1999

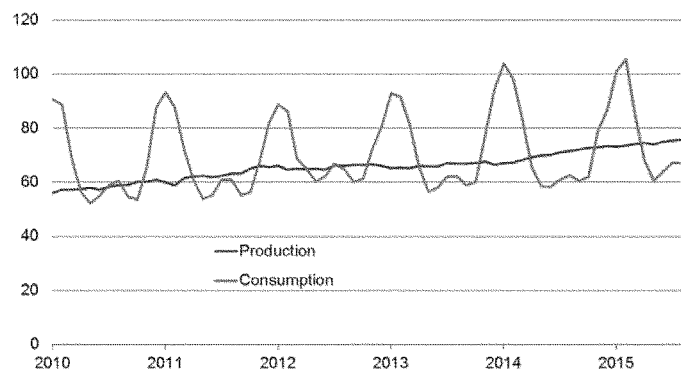
Monthly and annual average natural gas spot price at Henry Hub (1997-2015)
dollars per million British thermal unit



Source: U.S. Energy Information Administration, based on Thomson Reuters and Natural Gas Intelligence
Note: *2016 data are year-to-date average through January 11, 2016

Figure 4: U.S. natural gas production and consumption have increased

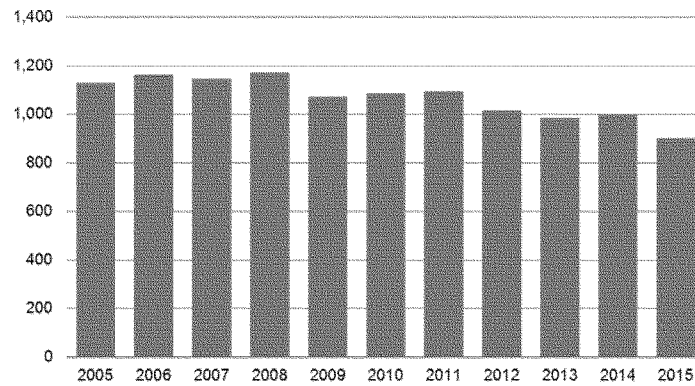
U.S. total monthly natural gas production and consumption
billion cubic feet per day



Source: U.S. Energy Information Administration

Figure 5: U.S. coal production declined in 2015

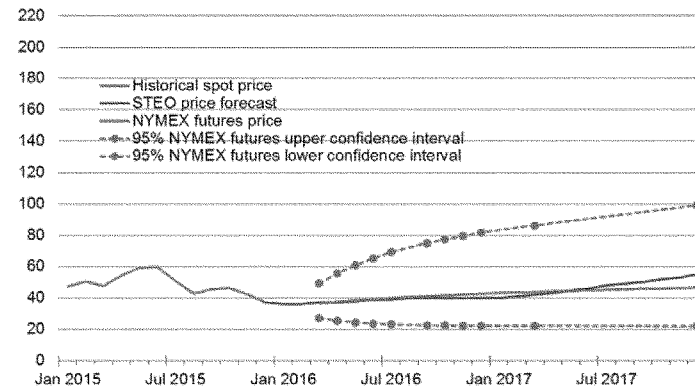
U.S. coal production
million short tons



Source: U.S. Energy Information Administration, Coal Data Browser

Figure 6: West Texas Intermediate (WTI) crude oil price and Nymex confidence intervals

WTI crude oil price
dollars per barrel



Source: EIA, Short-Term Energy Outlook, January 2016

Table 1: Non-hydro renewables expected to make up 9% of electricity generation by 2017

U.S. electricity generation by fuel, all sectors
share of total generation

Year	Coal	Natural Gas	Petroleum	Nuclear	Hydro Power	Non-hydro Renewables	Other
2008	48.2%	21.4%	1.1%	19.6%	6.0%	3.1%	0.6%
2009	44.4%	23.3%	1.0%	20.2%	6.8%	3.7%	0.6%
2010	44.8%	23.9%	0.9%	19.6%	6.2%	4.1%	0.6%
2011	42.3%	24.7%	0.7%	19.3%	7.6%	4.7%	0.6%
2012	37.4%	30.3%	0.6%	19.0%	6.7%	5.4%	0.6%
2013	38.9%	27.7%	0.7%	19.4%	6.5%	6.2%	0.7%
2014	38.6%	27.5%	0.7%	19.5%	6.2%	6.8%	0.6%
2015	33.8%	32.5%	0.7%	19.5%	5.7%	7.1%	0.6%
2016	33.6%	32.2%	0.7%	18.9%	6.0%	8.0%	0.6%
2017	33.0%	31.4%	0.7%	18.9%	6.4%	8.9%	0.6%

Source: Energy Information Administration, Short-Term Energy Outlook, January 2016

The CHAIRMAN. Mr. Sieminski, thank you very much. I am sure there will be questions.

Mr. Halff, welcome.

STATEMENT OF ANTOINE HALFF, SENIOR RESEARCH SCHOLAR AND DIRECTOR, GLOBAL OIL MARKET PROGRAM, CENTER ON GLOBAL ENERGY POLICY, COLUMBIA UNIVERSITY SCHOOL OF INTERNATIONAL AND PUBLIC AFFAIRS

Mr. HALFF. Thank you very much.

Chairman Murkowski, Ranking Member Cantwell, Senators Cassidy and Hoeven, I appreciate very much the opportunity to share some of my views here today and provide testimony. I'd like to focus on the oil market and take a step back on some numbers and try to identify some of the key drivers that I see as pushing the price lower.

The selloff, the scope, and the duration of the down turn in prices has come as a surprise to the market. It hasn't run its course. There's more room for lower prices but the selloff is not sustainable and eventually the price will rebound and the market will show a recovery. I think we'll emerge different from the recovery from what it was before.

This is not the first selloff in the market. There's been major price collapses about every ten years. This one is different because the market has changed in key ways on the supply side and on the demand side.

On the supply side two key factors are the advent of shale oil in the U.S., light, tight oil production and also the wave of social unrest and instability that is sweeping through many producing countries.

The impact of shale oil has made OPEC to give up its price management strategies, the practice of cutting supply to support prices with which OPEC has been identified over the last 30 years. There are three main reasons why that it so.

One reason is that shale oil has changed the perception of supply scarcity into a perception of supply abundance. It has unlocked huge resources, not just in the U.S. but potentially elsewhere in Argentina and Russia, and this has likely changed the view of major producers like Saudi Arabia about how best to optimize revenue from their resources.

The Saudi oil minister, Ali al-Naimi, for instance in the last 18 months or so, has repeatedly come back to the idea of what he calls a "Black Swan." The idea that in 20 years demand will not be there and Saudi Arabia might sit under a huge ocean of oil that's not worth as much as before. So it's essentially seemingly incentivized the users to speed up the base of extraction of their resource and maximize their revenue by selling more now and keeping less for future generations.

Another way in which shale oil has changed the picture is by shrinking the trade map for crude oil. The U.S. doesn't need to import as much crude as before. That is also the case of Europe because European refineries have found it difficult to compete with U.S. refineries which have increased their activity with the development of natural domestic resources in the U.S.

So there's less crude flowing into the U.S., less crude flowing into Europe. The market is now heavily concentrated in the eastern region, east of Suez in Asia and increasingly so in the next few years that makes it much more difficult for OPEC to cut production and allocate production cuts across the world when, in fact, OPEC producers, as other producers are increasingly competing with one another in a very fine like marketplace in Asia.

The third factor which limits the scope for OPEC to cut production is the way shale has changed the business cycle of the oil market. It's a much shorter business cycle. The shale industry, the shale companies are very different from traditional, conventional oil companies. They require less initial capital investment, they have much shorter lead times, much shorter payback times, and much steeper decline rates that are much more price responsive, at least in theory. So that means that if OPEC had clung to its old strategy of cutting supply it would, in effect, have subsidized shale production and enabled shale oil producers to come back in the market very quickly as soon as prices came back up. So it's not entirely a surprise that Saudi Arabia and the other OPEC members have given up the practice of cutting production.

Now, other producers also have been incentivized to produce more by the unrest in their countries. This is the case of Russia, this is the case of Iraq, this is the case of Brazil. This is the case—all these producers have been incentivized to produce more and to make up in volume what they've lost in per barrel price.

Now on the demand side, demand has also been very weak and that has undermined prices as well. The normal demand response that one might expect from a drop in prices has not happened for a number of reasons, the slow pace of the economy, the slowdown in China, changes in the currencies of major consuming countries and an effort to de-subsidize oil prices by a number of emerging economies.

In addition, the deflationary or quasi-deflationary environment in many economies has meant that low prices increase expectations of deflation instead of stimulating economic growth. And there's concerns in the oil sector about the rapid pace of penetration of competing fuels in traditional oil markets like natural gas and renewables.

So all these factors are changing the picture and mean that there's much more supply, much more downward pressure on prices. We are seeing now the beginning of a supply response, but supply continues to exceed demand. Inventories continue to build, and that means more pressure.

Longer term though, there will be a correction because the same factors that are incentivizing producers to maximize their revenue also incentivize them to cut their spending and invest very little in future production. So there's a lack of new projects to make up for decline rates and the decline rates themselves are increasing because necessary maintenance has been pushed back or reduced. So we're likely to see an increase in decline rates, an increase in the natural drop in production and the lack of new projects to make up for those declines.

So eventually we see a very steep rebound in prices when really would be shift in inventories which has an inflection points and even to restart drawing down.

This concludes my remarks, and I'd be very happy to take questions.

Thank you.

[The prepared statement of Mr. Halff follows:]



January 19, 2016

Congressional Testimony of

Antoine Halff

*Senior Research Scholar and Director of the Global Oil Market Program, Center on Global Energy Policy,
Columbia University School of International and Public Affairs*

Before the

Committee on Energy and Natural Resources

United States Senate

2nd Session, 114th Congress

Chairman Murkowski, Ranking Member Cantwell and Members of the Committee, thank you for inviting me here today to provide testimony on the global oil market outlook and the changes sweeping through the U.S. and international oil industry, not just in the United States but also globally.

Due to an array of market, economic, technological, policy-related and geopolitical forces, the oil industry is in the midst of a profound transformation. The interplay of these factors is a focus of the work undertaken by the Center on Global Energy Policy, an independent academic center at Columbia University's School of International and Public Affairs, which I joined recently to launch a new research program on global oil markets. The analysis that I will present today is based on my work at the Center as well as research I conducted earlier as Head of the Oil Industry and Markets Division at the International Energy Agency. It is also shaped by my prior experience as Lead Industry Economist at the U.S. Energy Information Administration, head of Commodities Research at brokerage Newedge USA, Director of the Global Energy practice at Eurasia Group and Adjunct Professor of International and Public Affairs at Columbia University.

Last week, as I was preparing these remarks, futures prices of Brent and U.S. West Texas Intermediate, the main crude oil benchmarks, slipped below \$30 per barrel, a 12-year low. That is a far cry from the highs of more than \$100 per barrel averaged for the period from 2011 to mid-2014. Few had seen the crash coming; even fewer predicted its scope and duration. Eight years ago, when WTI markets rallied to an all-time high of \$147/barrel, the prevailing narrative in oil markets was one of resource scarcity and runaway demand growth from China and other emerging economies. The specter of so-called 'resource wars' loomed large. Market participants were gripped by anxiety at the prospect of fierce international competition for dwindling resources. The idea that 'the age of easy oil is over' was the mantra of the day. The accepted wisdom was that prices have nowhere to go but up.

Since the beginning of the oil market selloff, roughly 18 months ago, early expectations of a rebound have been disappointed, and analysts have had repeatedly to push back their projections of a market recovery. Having failed to anticipate the price collapse and to predict its scope, market participants are now getting used to the idea that low oil prices have become the norm. "Lower for longer" is the new mantra. Automobile-industry executives, press reports tell us, are convinced that cheap oil is here to stay. At the time of writing, oil futures markets, admittedly a poor predictor of market conditions, were pricing crude oil for delivery in 2020 at less than \$50 per barrel. For the oil industry, the fear of too little has been replaced by anxiety over too much. Faced with a revenue meltdown, companies have slashed their spending by a total estimated at nearly \$400 billion. Tens of thousands of oil workers have been laid off, many of them in the United States. U.S. light oil imports, after a sustained period of decline, are rising again.



While it may be true that oil prices have yet to bottom out, expectations that cheap oil are the new norm are misguided. Predictions of long-term low oil prices will likely prove as wrong as the assumptions made just 18 months or two years ago of sustained, stubbornly high prices turned out to be. As in previous oil market cycles, a price correction is inevitable. Some of the very factors that have pushed prices down in the last 18 months will cause them to rebound in the next 18 months. And just as on the way down, the price swing upward may again surprise market participants by its speed, scope and duration.

Yet a rebound in prices, ineluctable as it may be, will not turn back the clock on the oil market. Nor will it mark a return to the status quo ante. The market that emerges from the current process of rebalancing will differ from the one that preceded it. The idea of a pendulum swing in oil markets is unexceptional; such swings have occurred in previous episodes of price correction. But this swing is different. When the dust settles, the market will have shifted, perhaps beyond recognition. The process of adjustment and restructuring ushered in by the price collapse marks the beginning of a new era in the history of oil and energy markets that will present both opportunities and daunting challenges for the industry.

What makes the current selloff and coming recovery different from previous market cycles is the advent of U.S. shale oil. The shale revolution has transformed oil market dynamics. It triggered the oil price collapse. It is now shaping the course of the recovery. It will eventually define the features of the energy landscape that will in due course emerge from the downturn.

Turning a glut into a bigger glut

The scope and duration of the selloff has defied expectations because of the surprising resilience of US shale oil production to remain high despite falling prices, but also because analysts had failed to anticipate that other producers would be incentivized to respond to a shale-induced supply glut by turning it into an even bigger glut. OPEC at its November 2014 meeting shocked the market by not cutting production in an attempt to balance the market and push prices higher. Since then, not only has the group refrained from reducing its output, but its two largest producers, Saudi Arabia and Iraq, have taken their production to new highs. So have other, non-OPEC, large producers like Russia and Brazil. This race to the top (or to the bottom in price terms) is a rational, predictable response to the new reality of shale production. But it is not sustainable.

Several factors account for the transformative impact of shale oil on supply dynamics. At roughly 4.5 million barrels per day today, U.S. shale oil makes up less than 5% of global oil supply. While that might not seem like much, just a few years U.S. shale production was zero. Shale oil alone accounts for the vast majority of the growth in non-OPEC oil production of the last few years. Advances in shale oil extraction technologies have caused ripple effects spanning the entire market and industry, both horizontally—throughout the oil-producing world—and vertically—across the supply chain. Shale oil in particular has led to a ‘regime change’ in oil pricing by forcing OPEC to throw away its playbook and put on hold the price-support policies that had defined it for the last 30 years.

Age of abundance?

There are at least three ways in which shale oil can be deemed revolutionary, each one of which has helped induce OPEC’s policy reversal. First, by unlocking vast resources that had long been deemed uneconomical, shale technology has upended the previous narrative of resource scarcity and dispelled ‘peak oil’ worries just as rising support for climate policies has cast doubt on the outlook for oil demand growth. This has raised speculation that large amounts of oil would have to ‘stay in the ground’ and fuelled concern about stranded assets, in turn changing the revenue-optimization formula for large, low-cost producers like Saudi Arabia. Shale has given Riyadh an incentive to speed up, rather than slow down, oil extraction.



In recent months, Saudi Oil Minister Ali al-Naimi has repeatedly evoked the prospect of what he called a ‘Black Swan,’ the risk that oil demand might fail to grow as forecast and leave vast amounts of oil unwanted – driven by technology improvements, more aggressive climate policy and structural changes in the economies of emerging markets. It is impossible to tell to what extent such concerns actually inform Saudi production strategy today. But the Kingdom has clearly messaged to the oil market that they were on its radar screen. Although seemingly long-term, these considerations have real, short-term policy implications.

A shrinking oil map

Another way in which shale oil changes the oil picture is by shrinking the global oil trade map. Surging U.S. shale production has curtailed the crude import needs not just of the United States but also of Europe. European refiners, faced with steep declines in domestic demand over the last decade, have struggled to compete with their cost-advantaged US counterparts, and have thus been importing less crude. Shale has accelerated the eastward migration of the crude oil market, the shift in its center of gravity to the so-called ‘East of Suez’ region. By 2020, Asia alone will account for no less than 65% of the crude oil market, according to projections from the International Energy Agency, up dramatically from levels as recently as 2014. That leaves crude oil exporters competing with each other in an increasingly concentrated Asian market itself dominated by supergiant Chinese oil trading companies with growing market power. In the past, OPEC oil exports were able to spread oil export cuts across their various export markets. Increased competition for Asian market share makes it extraordinarily hard for them to implement production cuts today, and even more difficult in the future.

A two-speed industry

Last but not least, the advent of the shale oil industry has been challenging the very business model of the oil industry. Oil companies have traditionally been large, deep-pocketed and professionally conservative, and have usually operated under a price umbrella of one kind or another: Rockefeller’s Standard Oil, the Seven Sisters, OPEC. Shale oil companies – small, nimble, highly leveraged, intensely adaptable – break that mold. Whereas conventional oil production requires large upfront investment and lead times measured in years if not decades, the shale business cycle is shorter: upfront shale costs are relatively low; decline rates are steep; lead times and payback times are measured in months rather than years. This shift to a two-speed industry – contrasting long-cycle conventional projects and short-cycle shale production – makes OPEC production cuts an impractical and inefficient way to support prices, as shale producers can swiftly respond to upward price movements by boosting investment and ramping up output in short order, thus defeating the purpose of the cuts. As long as shale production capacity is not durably degraded, any attempt by OPEC to retrench and lift prices runs the risk of effectively subsidizing shale producers and abandoning market share to them.

Producer-country budget needs

The socio-political context of the recent selloff – including unrest and conflict across parts of the oil-rich Middle East and North Africa – has compounded the impact of shale supply growth by boosting the budget needs of oil export-revenue-dependent producer countries. Falling oil prices are not a recipe for social stability in countries that depend on oil income for social spending. That has incentivized oil exporters to boost production against all odds and to respond to lower oil prices by maximizing production volumes to the extent possible.

The greater the odds faced by oil producers in the last 18 months, the higher their exports have been. In Iraq, low prices combined with the ISIS conflict have unlocked unprecedented supply growth, pushing Baghdad to resolve in a hurry above-ground bottlenecks that had held up production for years. In Russia, the dire needs



caused by the conjunction of low prices and international sanctions have sent supply on a tear. Faced with a currency collapse, falling oil revenues and a crippling corruption scandal at its national oil company, Brazil has outperformed and broken new supply records since the beginning of the market rout. Venezuela and Nigeria, with no financial buffers to cushion the impact of falling revenues, have both managed to maintain relatively high production.

Sluggish demand response

While supply has responded to low prices in a counter-intuitive way, demand – with the notable exceptions of the United States – has also surprised by failing to show any significant demand growth that cheaper supplies would normally stimulate. Several short-term factors account for this lack of consumer response: the general weakness of the global economy, the lack of wage growth, the weakening currencies of many consumer economies, deflationary pressures, shifts in consumer behavior, policy moves to reduce oil subsidies in emerging markets, environmental measures and efficiency improvements. In a deflationary or quasi-deflationary environment such as has been experienced in Europe and Japan, low prices may feed into expectations of deflation – thus delaying business and household spending – rather than act as economic stimulus. Currency depreciation has also offset oil price declines for many end-users, depriving them of the full economic benefit of the crude price drops.

Long-term demand uncertainty

Meanwhile, climate policy and inter-fuel competition are chipping away at the oil market's longer-term prospects, with natural gas maturing into a global market and seemingly poised to make inroads in the transportation sector that oil has long dominated, displacing diesel for trucks or residual fuel oil for bunkers. Oil's role in the global economy and its place in the energy mix are changing, driven by a combination of technological, demographic, economic, social and policy shifts. The oil intensity of the global economy is evolving. Oil efficiency is improving. Inter-fuel competition erodes oil's market share, as the natural gas market globalizes and renewable energy costs fall faster than expected. Environmental policy is gaining momentum, and could reach a tipping point leading to significant reductions in hydrocarbon demand. Technological advances, such as a potential breakthrough in energy storage that would lead to a precipitous decline in oil demand, no longer seem beyond reach. All this fans concerns over the demand sustainability and may be feeding into the policy decisions described earlier that maximize oil output today, even at a comparatively low price.

The flip side of today's high production

While many factors on both the current supply and demand situation conspire to create the market's massive imbalance and a consequent build up of global inventories, the resulting bearish pressures on oil prices are unsustainable. The flip side of the revenue maximization policies that helped exacerbate today's oversupply is the industry's new drive to minimize spending and cut costs. (Saudi Arabia and its Gulf Cooperation Council neighbors buck the trend here and have maintained relatively high spending despite the price decline.) This will inevitably lead to lower production tomorrow and may result into a supply shortfall.

The effects of project delays on future supply is well documented and broadly understood. Oversupply today is in part the result of short-cycle shale production as well as higher-cost, larger-scale projects for which investment was deployed years ago and which are only now coming to fruition. But the incremental impact of those legacy large scale or lagged projects is on the wane, and a lack of follow-up projects will soon cause production growth to flatten out and shift into reverse.



Less well understood is the impact of delayed field maintenance – another form of current cost savings – on decline rates and future production. Decline rates are, generally speaking, poorly measured, but it is virtually certain that costs savings achieved by companies by pushing back work on oil fields will cause production decline rates to steepen appreciably. The lack of new major projects will exacerbate the challenge of making up for that shortfall.

Steeper decline rates, spending cuts resulting in project delays and capital constraints in the shale oil industry due to low prices will likely more than make up for an expected increase in Iranian oil exports following the lifting of some US and European sanctions, and will likely lead to inventory draws – thus supporting oil prices – potentially as soon as the end of this year.

Political supply risk

Meanwhile, political risk to supply remains elevated in the wake of rising social unrest and weakening oil revenues in several producer countries. Iraq's ability to further grow production, which it needs to finance its military, may run into headwinds due to its failure to deliver payment to the international oil companies active in the country. The risks of social disruptions in oil producing countries that have little protection against downswings in oil prices, chief among them Venezuela, cannot be ignored.

Shale oil as swing producer?

Shale oil's response to the rebalancing is a wild card. Due to its shorter cycle and low initial fixed costs, the shale oil industry has in theory the capacity to respond quickly to price signals and to ramp up production early in a rebound. After a period of resilience, shale oil has been the first respondent to the price decline, with production losses projected for 2016 estimated at around 700,000 barrels per day year-on-year. It may again be the first respondent on the way up. Certainly that prospect has the potential to act as a deterrent against longer-cycle investments into conventional high-cost production.

Whether the shale oil industry will in fact retain its full capacity to rebound through the downturn is highly uncertain, however. Shale oil companies face two major constraints: access to capital – which may be degraded, especially in the event of interest-rate hikes – and access to labor markets – which will suffer from the current round of layoffs. Restructuring and consolidation in the shale oil patch may also lead to changes in the management of shale oil assets if they are acquired by larger companies with more diversified portfolios and different interests than the current owners. Finally, while the industry has achieved impressive costs savings since the beginning of the price drop, some of these costs reductions may be cyclical and subject to reverse as soon as rising prices rekindle demand for oil services.

Conclusion: A new era of heightened volatility?

In summary, the oil market is facing unprecedented headwinds, which have resulted in steep and, for the industry, highly challenging price declines. While supply growth is already slowing in the face of shale oil setbacks, oversupply and inventory builds continue amid relatively sluggish demand growth. Downward pressures on oil prices will persist until the market reaches an inflection point and inventories decline.

But the factors that today incentivize producers to boost output at the expense of longer-term investment will inevitably undermine future production. The very rise of the shale oil industry, with its unique cost structure and short business cycle, undermines longer-term investment in high-cost conventional supply. The ability of the shale industry to ramp back production in a rebound is untested, however, and the market might find out when prices finally recover that its capacity has been durably degraded. In a best-case scenario, the market ought to brace itself for a period of heightened volatility, albeit perhaps in a relatively narrow band, if the



shale oil industry manages to function as an effective swing producer. Alternatively, low prices today may set the stage for significant supply shortfalls tomorrow.

This concludes my testimony, Madam Chairman and Members of the Committee. I would be happy to answer any questions you may have.

The CHAIRMAN. Thank you.
Mr. Lucier?

**STATEMENT OF JAMES LUCIER, JR., MANAGING DIRECTOR,
CAPITAL ALPHA PARTNERS LLC**

Mr. LUCIER. Well Chairman Murkowski, Ranking Member Cantwell, Senator Cassidy, Senator Hoeven, thank you for the opportunity to testify before this Committee. I'm honored that you'd request my views on the state of the electric power industry and the power markets. In these remarks I'll present high level views on electric utilities, merchant power producers and the critical issues of price formation and market structure in the wholesale power markets.

My name is James Lucier, and I'm a Managing Director and Head of the Energy Practice at Capital Alpha Partners. That's an independent research and advisory firm that serves mostly institutional asset managers and financial participants in the power markets.

I personally have been devoting the bulk of my time to the electric power industry and to the power markets since I first started following them as an analyst at the Prudential Equity Group in the California power crisis of 2001, 2000–2001 actually. So it's been an interesting 16 years.

If I were to characterize the state of the power markets in five points I would offer the following.

First, inflation adjusted retail power prices are at historically low levels but also consistent with the historically stable range showing that the system and the industry, generally, have served consumers well by maintaining low and stable prices over a considerable period of time.

Also, wholesale power prices are similarly at a ten-year low which again shows service to consumers but also reflects low interest rates and low natural gas prices which cannot be taken for granted and possible design flaws in the wholesale power markets which, I believe, may not be sustainable.

In the regulated utility space, corporate management faces a conundrum, how to maintain or increase earnings to satisfy shareholders at a time when power demand, after declining year on year for the first time in U.S. history after 2008, remains flat or nearly flat as far as the eye can see which is to say well into the forecastable future.

In the merchant power space generators are hard pressed to show a return on equity that would justify new investment in competitive markets that serve two-thirds of the U.S. population. A step change downward in natural gas prices since 2008 which we will credit to the shale revolution is part of the story but so also are troublesome issues, price formation in the energy markets and the development of appropriate pricing mechanisms for reliability and ancillary services.

Finally, as this Committee knows so well, the demands of the EPA's Clean Power Plan will drive the greatest investment cycle ever in the history of the U.S. power industry, perhaps amounting to hundreds of billions of dollars as existing baseload power plants retire beginning, as we've already seen, with the mercury and air

toxic standards, MATS, driven cycle of 2015 and continuing through 2030 and beyond.

The single greatest challenge in the power markets today is financing the technology investment and the infrastructure upgrade cycle needed to replace retiring base load and to handle new, perhaps even unforeseen, demands between now, 2030 and beyond. This challenge must be dealt with now in a prudent, thoughtful and timely manner lest due to failure to act consumer price increases that could be managed or mitigated now become disruptive price shocks later.

The power industry has been battered by a series of exogenous shocks, including interest rates, commodity prices and the lingering effects of the great recession of 2008. But at the same time this always evolving industry is in a period of rapid technological innovation.

Policy makers should take a balanced, long-term view looking to maintain a diversity of options long into the future. New technology and innovation by all participants should be welcomed. But at the same time, policymakers should recognize that the existing infrastructure with its diversity of business models, fuel types and public or private ownership represents not just the spinning reserve or fly wheel that keeps power flowing, but also the deep pool of invested capital that keeps the system working financially as well.

That concludes my remarks. I look forward to your questions.
[The prepared statement of Mr. Lucier follows:]

Testimony of James P. Lucier, Jr.
Managing Director, Capital Alpha Partners LLC
Before the Senate Committee on Energy and Natural Resources
Hearing to Examine the Near-Term Outlook for Energy & Commodity Markets
January 19, 2016

My name is James Lucier, and I am a managing director and head of the energy practice at Capital Alpha Partners, an independent research and advisory firm that serves mostly institutional asset managers and financial participants in the power markets.

Inflation-adjusted retail power prices are at a historically low level, but also consistent with a historically stable range, showing that the system and the industry have generally served consumers well by maintaining low and stable prices over a considerable period of time.

Wholesale power prices are similarly at a ten-year low, which again shows service to consumers but also reflects low interest rates and low natural gas prices, which cannot be taken for granted, and possible design flaws in the markets that I believe may not be sustainable.

In the regulated utility space, corporate management faces a conundrum: how to maintain or increase earnings to satisfy shareholders at a time when power demand, after declining year on year for the first time in U.S. history after 2008, remains flat or nearly flat as far as the eye can see, which is to say well into the forecastable future.

In the merchant power space, generators are hard pressed to show a return on equity that would justify new investment in competitive markets that serve two-thirds of the U.S. population. A step change downward in natural gas prices since 2008, which we will credit to the Shale Revolution, is part of the story, but so also are troublesome issues with price formation in the energy markets and the development of appropriate pricing mechanisms for reliability and ancillary services.

Finally, as this committee knows so well, the demands of the EPA's Clean Power Plan will drive the greatest investment cycle ever in the history of the U.S. power industry, perhaps amounting to hundreds of billions of dollars, as existing baseload power plants retire, beginning as we have already seen with the Mercury and Air Toxics Standard (MATS)-driven cycle of 2015 and continuing onward through 2030 and beyond.

The single greatest challenge in the power markets today is financing the technology investment and infrastructure upgrade cycle needed to replace retiring baseload and handle new, perhaps even unforeseen, demands between now, 2030, and beyond.

This challenge must be dealt with now, in a prudent, thoughtful, and timely manner, lest, due to failure to act, consumer price increases that could be managed or mitigated now become disruptive price shocks later.

Policy makers must take a balanced, long term view, looking to maintain a diversity of options long into the future. New technology and innovation by all participants should be welcomed. But at the time, policy makers should recognize that the existing infrastructure—in its diversity of business models, fuel types, and public or private ownership—represents not just the spinning reserve or the flywheel that keeps power flowing but the deep pool of capital that sustains the system financially as well.

Hearing to Examine the Near-Term Outlook for Energy & Commodity Markets

January 19, 2016

Thank you for the opportunity to testify before this committee. I am honored that you would request my views on the state of the electric power industry and the power markets. In these remarks I will present high level views on electric utilities, merchant power producers, and the critical issues of price formation and market structure in the wholesale power markets.

My name is James Lucier, and I am a managing director and head of the energy practice at Capital Alpha Partners, an independent research and advisory firm that stands at the intersection of the financial markets and public policy. Our clients include institutional asset managers, investment banks, commodity trading firms, private equity investors, and corporate management.

I personally have been devoting the bulk of my time to the electric power industry and the power markets since I first started following them as an analyst at Prudential Equity Group during the California power crisis of 2000 and 2001. It has been an interesting 16 years.

Overview

I appreciate the committee's close and careful attention to the power markets and the electric power industry as evidenced by this hearing and many others. I would particularly like to commend the committee for its the important hearing of March 17, 2015 on "The State of Technological Innovation Related to the Electric Grid," which placed a keen and timely focus on distributed generation. Chairman Murkowski and Ranking Member Cantwell have both distinguished themselves with a stream of thoughtful policy papers, reports, letters, statements, and other documents on the subjects of electric power and energy that go far beyond the usual committee publications.

The five points that best characterize the state of the power markets and the electric power industry are these:

- **Low retail prices.** Inflation-adjusted retail power prices are at a historically low level, but also consistent with a historically stable range, showing that the system and the industry have generally served consumers well by maintaining low and stable prices over a considerable period of time.
- **Low wholesale prices.** Wholesale power prices are similarly at a ten-year low, which again shows service to consumers but also reflects low interest rates and low natural gas prices, which cannot be taken for granted, and design flaws in the wholesale power markets, which are currently not providing the economic returns required to keep necessary baseload power in operation or to attract new investment.

- **The changing utility business model.** Investor-owned, regulated utilities face a conundrum: how to increase earnings at a time when power demand is essentially flat. U.S. power demand declined year on year in 2009 for the first time in U.S. history, and only now has power demand barely returned to pre-recession levels. The outlook for demand growth remains flat or nearly flat as far as they eye can see.
- **Broken wholesale markets.** In the merchant power space, generators are hard pressed to show a return on equity that would justify new investment in competitive markets that serve two-thirds of the U.S. population. A step change downward in natural gas prices since 2008, which we will credit to the Shale Revolution, is part of the story, but so also are troublesome issues with price formation in the energy markets and the development of appropriate pricing mechanisms for reliability and ancillary services. In other words, the scarcity-pricing model as currently deployed is not well suited to an age of energy abundance. Consumers pay for energy only, and not for reliability, which is unsustainable in the long run. Meanwhile, as generators struggle, state governments concerned about reliability and reserve margins understandably seek out-of-market solutions without waiting for the markets and the market operators to adjust, sending mixed signals to the capital markets, calling the wholesale market framework into question, and ultimately helping no one. Mixed signals about Washington's commitment to the wholesale markets further add to the problem.
- **A new investment cycle.** Finally, as this committee knows so well, the demands of the EPA's Clean Power Plan will drive the greatest investment cycle ever in the history of the U.S. power industry, perhaps amounting to hundreds of billions of dollars, as existing baseload power plants retire. We have seen the cycle begin already with the Mercury and Air Toxics Standard (MATS)-driven cycle of 2015. We will see it continue through the CPP-driven cycle of 2030; and we will see it continue beyond that, as even the cleanest of existing baseload plants, including nuclear power plants, reach the end of their useful or design lives.

In short, the single greatest challenge in the power industry today is financing the technology investment and infrastructure upgrade cycle needed to replace retiring and baseload maintain electric reliability between now and 2030. The industry must cope with powerful forces of endogenous change at the same that it is buffeted by a wide variety of exogenous shocks and forces. A supportive public policy environment, one that gives confidence to long-term fixed capital investments, is essential.

Policy Challenges

Electric power is an essential public service and the lifeblood of the economy that is increasingly digital as well as physical. Electricity underlies public health and safety, national security, and all other aspects of our national well-being.

The U.S. power grid is the largest, most complex engineered structure on the face of the earth. It is also the oldest, most diverse, and variegated of any such structure at this scale. The working power grid represents a complex ecosystem of infrastructure, skilled labor, and distributed information processing that is sustained by cash flows, large pools of invested capital, and ongoing access to the financial markets. Every element of this equation demands attention. It is counterproductive to starve one element to feed another.

The power markets and the power grid present a number of challenges to U.S. policymakers. Some of these are traditional, such as:

- the need to work in partnership and collegiality at the federal and state levels;
- regional diversity, and the proliferation of both investor-owned and public power business models;
- the dynamic character of the markets, in which supply and demand must be balanced on the grid in real time.

New challenges include:

- the need to maintain the economic viability of baseload power;
- the need to modernize and upgrade the power grid and the labor force which maintains it;
- the need to address existing challenges to the scarcity pricing model for wholesale power;
- the need to incorporate new technologies into the grid—particularly distributed generation, storage, energy efficiency, and demand response—which could exacerbate the pressure on scarcity pricing given current market designs.

Current Industry Conditions

One way to observe the state of the power industry is to look at the recent performance of publicly traded companies in the equity markets. It is not a perfect indicator, but it does serve as a barometer of investor sentiment, and it is particularly useful in highlighting the issues that investors are most concerned about. This is not to slight public power entities, since those entities often face many of the same issues and concerns, particularly with respect to their financing needs, albeit in a different way. The bottom line is that last year was challenging on all fronts.

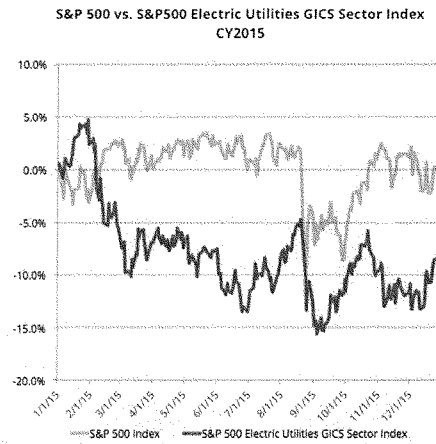
We will start with regulated utilities, which are in many ways the best-situated companies in the space. They were standout performers in 2014, but had a rough year in Calendar Year (CY) 2015.

The Dow Jones Utility Index, an index of 15 mostly regulated utilities, was down 7.04% in calendar year CY 2015. The S&P 500 Electric Utilities Sector Index of regulated electric utilities was down 9.1% in the same period. By contrast, the broad market indices were only slightly down or flat for the year. The Dow Jones Industrial Average was down 2.3% for the year while the S&P 500 was down .7%.

However, the year-end numbers don't tell the whole story, since stocks took a beating in the first half of the year and then again in the fall, but rallied late in the year to make the year end numbers less dismal than they might have. Key factors early on were rising interest rates, particularly the 10-year Treasury, in anticipation of a Fed rate hike at the end of the year, and warm weather, El Nino-driven, cheap natural gas prices. Stocks recovered when gas tightened and investors began to look beyond the Fed's rate increase.

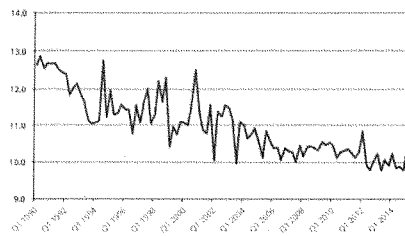
But ironically in 2015, despite concern about the Fed's imminent rate increase, the Fed's long-time low interest rate policy also applied downward pressure as it filtered through, or threatened to filter through, to regulated ROEs. Individual utility performance was a mixed bag, depending on asset mix and other factors, with AEP down 4.75% and PSEG down 7.7%, but FirstEnergy down 19.1%, Entergy down 22.1%, and Exelon down 26.1%. It was not a good year to be nuclear.

Electric utility stocks lagged the broader market return by 9 percentage points in 2015.

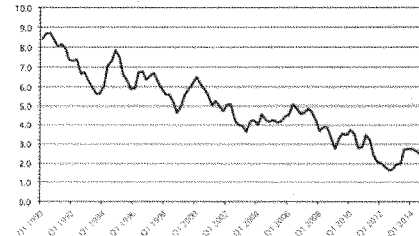


Data Source: Bloomberg, L.P. (2016) Stock price data charting "SPX Index" and "S5ELUT". Retrieved February 5, 2016.

**Long-term Allowed State-level Electric Utility ROE
Q1 1990 - Q1 2015**



**Long-term Average 10-year Treasury Yield
Q1 1990 - Q1 2015**



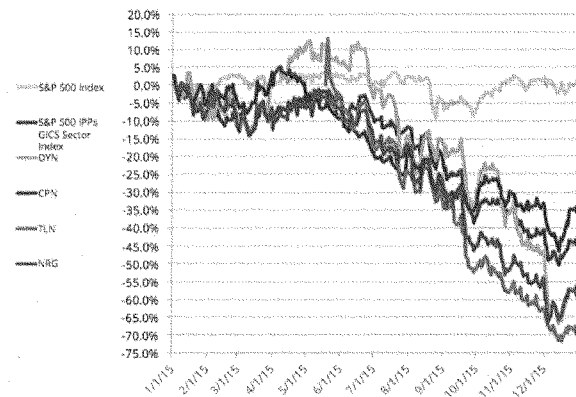
Allowed state level ROEs have followed ten year interest rates on Treasury notes downward, long-term.

Data Source: Edison Electric Institute (EEI), 2015 Q3 Financial Updates, Rate Case Summary Backup Data, <http://www.eei.org/resourcesandmedia/industrydataanalysis/industryfinancialanalysis/QtrlyFinancialUpdates/Pages/default.aspx>

Merchant power companies got off to a similar rough start at the beginning of 2015, but unfortunately for them, there was no relief and partial recovery in the second half. Instead, things got worse, and got worse faster. The S&P 500 Independent Power Producers & Energy Traders Sector Index finished the year down 43%. Individual names suffered notably, with Calpine down 36.3%, Dynegy down 56.4%, NRG down 57.2%, and Talen down 70.0%. Natural gas was probably a dominant factor, but ongoing concerns over market structure, out-of-market developments, and uncertainty over major market structure cases before the Supreme Court also weighed on the group. Oil was a factor as well, with the commodity price drop tearing through the energy sector. As these issues weighed on the group, high-yield bond markets tightened, restricting the terms and availability of credit.

Merchant power companies sold off as much as 70% in the course of the year, while the overall index was down 43%.

**S&P 500 vs. Merchant Power Equities
CY2015**



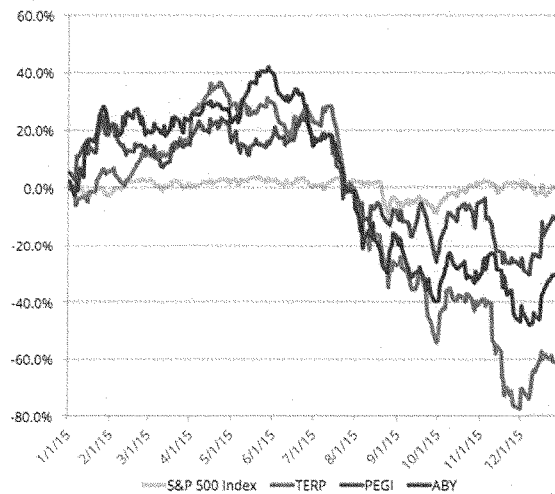
Data Source: Bloomberg, L.P. (2016) Stock price data charting "SPX Index", "SSIPPE", "DYN", "CPN", "TLN", "NRG". Retrieved February 5, 2016.

Yieldcos also saw a steep selloff. We include them here even though they don't strictly have a bearing on power. Rather, they illustrate the type of unexpected cross current we mentioned earlier.

The plunge in yieldco prices began in summer and intensified in early fall. The initial slide may have resulted from cross-selling by investors to cover oil-related losses (that is, by income-oriented investors also holding MLPs), even though the yieldcos held no assets with earnings linked to oil. But declines in their share prices and thus valuations also meant a higher cost of equity financing for the yieldcos and thus a higher return bar for project acquisitions and thus earnings growth. Among prominent names, Abengoa Yield was down 30.7% for the year, Terraform Global was down 60.1%, and NRG Yield was down 70.2%. Of course, many investors feel these companies have excellent prospects for the future. Our point is simply to emphasize the volatility in last year's financial markets, and the markets generally, which move much faster and less predictably than discussions in the policy world.

Yieldcos saw a stiff selloff mid-year.

**S&P 500 vs. Yieldco Equities
CY2015**



Data Source: Bloomberg, L.P. (2016) Stock price data charting "SPX Index", "TERP", "PEGI", "ABY". Retrieved February 5, 2016.

Power Markets

For merchant power, a key backdrop to these developments is that power prices continue to decline, following a long term trend. According to EIA, wholesale peak-hour power prices declined 27-37% YoY, according to a January 11 *Today in Energy* release. (See below.)

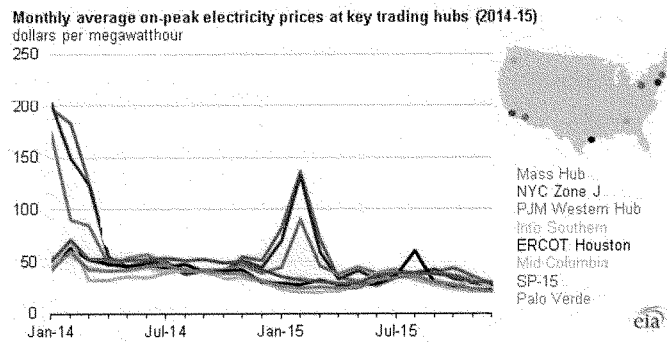


Image Source: Energy Information Administration (EIA), January 11, 2016, *Today in Energy*, <http://www.eia.gov/todayinenergy/detail.cfm?id=24492&src=email#>

We will discuss key factors behind the low wholesale power prices later in this testimony. Despite the low price environment, there were still some encouraging signs.

The major RTOs and ISOs have begun to move forward with improved reliability pricing in their capacity market designs. After extensive review, FERC approved PJM's Capacity Performance design changes on June 9, 2015. The rule changes reward generators for reliable performance during power shortage events. For ISO New England, FERC approved similar Pay for Performance design changes in May of 2014, and recently upheld the changes in a rehearing order released in November. FERC is also moving forward with technical changes to energy and ancillary services markets rules to improve price formation, via an inquiry initiated in late 2014. The inquiry has resulted in several technical conferences, staff workshops and a proposed rule on scarcity pricing, but many in the industry may feel the inquiry should be moving faster given market conditions described above.

But the uncertain legal and regulatory outlook for the wholesale markets weighs on investor sentiment nonetheless. Key litigation at the Supreme Court around demand response—resolved in January—and state-level capacity procurement “contracts for differences” had the potential to significantly alter the supply-demand landscape in energy and capacity markets.

Meanwhile, alarmed at the lack of new entry in the generation markets, states are choosing to assert their traditional roles in resource adequacy and to act independently of markets to ensure reliability amid fears of premature resource retirements and constraints in later years. Some notable instances include:

- Ohio - The Ohio PUC is currently reviewing contracts between FirstEnergy and AEP load-serving utilities and their independent generator affiliates that would provide long-term fixed income to plants that might otherwise retire under current short-term market conditions.
- Illinois - MISO, Illinois regulators and legislators are considering various measures that would sustain at-risk plants in Illinois through current market conditions. Some parties are especially concerned about the implications for Clean Power Plan compliance if several nuclear plants in the state retire.
- Maryland - Maryland, as early as 2012, sought to procure additional capacity for reliability purposes via a "Contract-for-Differences" capacity and energy arrangement, procured by a competitive bidding process, that resulted in the procurement of power from a new 661 MW CCGT plant from CPV Maryland. The CfD scheme, which dictates credits or payments from load to CPV based off of the clearing price in PJM auctions, is currently under review in two consolidated cases — the "Maryland cases"—at the Supreme Court. These are being considered in the same term as *FERC v. EPSA*, the demand response case mentioned previously. A petition for cert. in cases surrounding a similar CfD program in New Jersey is pending at the Supreme Court.

Natural Gas Pipelines

Timely construction of natural gas pipelines remains a concern, for both takeaway and delivery. Appalachian basin shale gas trading hubs, even in current winter months, are trading at a deep discount to Henry Hub gas and other major hubs. The discount flows through to power prices, putting additional pressure on struggling baseload coal and nuclear plants in the Marcellus and adjoining regions, where many such plants are located. Planned takeaway capacity is set to grow significantly, if production isn't curtailed before then, but opposition to infrastructure development could prolong the supply glut and put the timing of relief in question, maintaining the negative outlook for power producers.

Elsewhere, gas delivery is the major concern. The number of new pipelines needed to support gas fired power plants and the transition to the Clean Power Plan has strained available resources at FERC, and there are some signs pipeline approvals may be slowing down. This is not helped, for particular pipelines, by a rising tide of opposition to pipelines to pipelines by environmental groups that oppose construction of any pipeline, for any reason.

Of notably high concern on the gas delivery front is New England. The Polar Vortex of 2014 remains an unhappy memory this year, though its urgent clarion call helpfully called attention to electric reliability and fuel delivery supply chains throughout the country. Even now, in lingering El Niño conditions, New England power and gas prices are still higher than elsewhere in the Winter and reflect infrastructure constraints that could cause problems in future severe winters, especially as the region becomes even more reliant on natural gas and non-gas plants, such as the 680MW Pilgrim Nuclear Plant, retire. Though the pace of gas pipeline infrastructure into New England has picked up a bit - with several major projects proposed, such as the Northeast Energy Direct pipeline and the Access Northeast pipeline - progress remains painfully slow.

Nuclear Power

On the nuclear front, Entergy's Pilgrim and Fitzpatrick plants were the latest to announce closures last year. Exelon's Ginna plant remains in operation due to a reliability agreement, while the Byron, Clinton, and Quad Cities nuclear plants in Illinois remain widely considered at risk. The Illinois legislature has been debating legislation that would institute a "Low Carbon Energy Standard" nuclear power procurement program, but the legislation has been slow to move in that state. Meanwhile, the Clean Power Plan's final rule provided little in the way of explicit support for nuclear that investors were hoping for, leaving the fate of nuclear power to whether states could develop a sufficiently robust carbon price on their own. Issues facing nuclear power include low gas prices, increasing operating and maintenance (O&M) costs due to post-Fukushima regulations, and competition from zero-marginal cost renewables placed lower in the dispatch curve.

Transmission

Electric transmission remains a key source of frustration for investors who regard long distance transmission assets, in principle, as being highly investible and yet have few, if any projects to invest in. Some investors argue that the FERC Order 1000 process, once the source of high hopes, does not seem to be working as intended to expedite siting decision. Others say Order 1000 can yet deliver results, but we are still in the early stages of compliance. This might well be an appropriate area for committee oversight. Meanwhile, investors who have lost patience with "lumpy" large transmission projects are looking for opportunity in the distribution-level grid where steady incremental progress is more consistent.

Distributed Renewables

We look at fundamental factors behind distributed renewable generation later in the testimony. The most notable recent developments vary state by state. On the whole, state regulators seem to be looking for ways to accommodate distributed generation (DG)

resources by offering a reasonable price for power and charging a reasonable price for grid access.

- Nevada - The Nevada PUC in December unanimously finalized a new net metering rate design that would gradually reduce the value of credits for excess generation from net metered customers and impose a higher service charge for rooftop solar customers. The PUC recently refused to stay the order, and in response SunRun and SolarCity have announced significant drawbacks in their operations in the state.
- Mississippi - Mississippi finalized mandatory net metering rate regulations for the first time ever in December. The final decision sets the rate for excess generation paid to net metering customers equal to wholesale power cost plus 2.5 cents, far lower than the retail rate value enjoyed by solar resources in other states, and sets a cap on net metered systems equal to 3% of capacity.
- California - A recent innovative proposal from California regulators would impose a one-time interconnection fee on DG customers, a payment based on gross power consumption, and time-of-use rates for DG solar power sold back to the grid. The CPUC is still considering the proposal.

Macro Shocks and Cross Currents

Most discussion of the power industry start with internal, organic changes in the industry driven by technology and changes in market place demand. We think that is useful, but in this case we prefer to start with a list of the external, often unexpected forces that impinge on the industry in a decidedly mixed set of ways. These factors--global economics, monetary policy, commodity prices, weather, and even natural disasters--are seldom part of the policy discussion despite their foundational importance to business realities.

- **Economic Shock.** The Great Recession of 2008 is still with us, leaving unresolved the question of whether it broke the historical relationship between power demand and GDP, which previously had moved together in lockstep. Power demand dropped year on year for the first time in 2009. Overall demand has barely returned to 2008 levels. Industrial demand is down, commercial demand is recovering, and residential demand does seem to be growing a bit.
- **Interest Rates.** As we have noted, utilities are interest-rate sensitive stocks. Rising interest rates put pressure on valuations, and the Fed's move to tighten this year has had a strong impact. Meanwhile, the Fed's long period of near-zero interest rates has cut both ways. A low interest rate environment has reduced the cost of infrastructure investments, which is a positive for investors. But it has also exerted

downward force on ROEs for existing assets, both at the federal and state level, discouraging shareholders and making it harder for utilities to attract new capital.

- **Natural Gas.** The Shale Revolution is not a one-time event but a sustained, paradigm-shattering assault on all that went before. It is hard to recall that even in 2008, a recession year, natural gas prices averaged \$8/mcf for the year and peaked at \$14/mcf. By 2012, natural gas in the \$2-3/mcf range felt like the stunning new normal, and it did so again this year.
- **Crude Oil.** Natural gas is not the only commodity price that matters. The collapse in the Nymex front-month futures contract price of oil from its high of \$107.26 in June 2014 to less than \$30 today, a twelve-year low, has had outsized impact on electricity infrastructure investments because of its negative impact on the energy sector generally, energy infrastructure, and fixed income markets, as well as the economy as a whole as energy sector supply chain deflation drastically cuts overall capex.
- **Weather Effects.** Weather has a major impact on natural gas prices and the power industry. It can also impact the deliverability of fuels such as coal, highlighting the importance of fuel diversity. The year 2014 was the year of the polar vortex—at both the beginning and end of the year, which posed a major test to the reliability and resiliency of the U.S. power system. This year, El Niño has posed a different problem in the form a gas glut. Meanwhile, the price of coal has fallen due to a steep drop in demand and oversupply. Coal's value as an economic hedge against natural gas price volatility has been diminished by the new supply of gas from shale but coal remains an important hedge against future weather events such as the next polar vortex. Meanwhile, in New England, the deliverability of gas remains an area of prime concern.
- **Natural Disasters.** The Fukushima Earthquake of 2011 comes most prominently to mind, but the same year saw flooding in the Missouri River and an earthquake in Virginia which affected, though modestly, U.S. nuclear plants. The NRC's follow-on regulations have raised, and may continue to raise, nuclear O&M costs in a way which is unhelpful in a low-price environment.

Challenges to Utility Business Models

From the opening of Thomas Edison's Pearl Street Station in 1882 through the heyday of Samuel Insull in the 1920s and well into the post-World War II era, the prevailing business model for investor-owned utilities rested on two assumptions: economies of scale, and presumed natural monopolies. A regulated rate of return on large fixed capital investments made it possible to secure private financing for these otherwise risky experiments. The system was not perfect. On the one hand, through the phenomenon of regulatory capture,

where regulators identify with the interests of the industry they regulate, and risk-averse elected officials prefer to be safe rather than sorry, it is arguable that cost-based regulation has a long term tendency to overinvestment. On the other hand, the efficiency gains available through scale economies kept consumer prices steadily falling in real terms throughout the era.

The system began to reach its limits in the 1970s, when large nuclear and coal-fired power plants and the transmission infrastructure needed to support them became increasingly expensive and difficult to site. The scale economies also began to run out. The decade of the '70s became known for cost overruns, most notably on nuclear projects, utility bankruptcies, and rate shocks. At the same time, wide reserve margins suggested that existing generation plants were under used.

One response at the federal level was the Public Utility Regulatory Policies Act (PURPA) of 1978 which promoted co-generation and allowed non-utility generators to connect to the grid and sell power for avoided costs as an alternative to meeting public needs through large, central power plants. Meanwhile the states looked for their own strategies to manage costs through improved rationalization. In the 1980s, "Integrated Resource Planning" (IRP) became the watchword of the day, while in academe pioneering researchers began to postulate a competitive market in generation services. The combined cycle gas turbine, long in development, fortuitously emerged from the aerospace world at this time to make competitive markets a reality.

Combined cycle gas offered high levels of efficiency at relatively low cost, in conveniently small, modular units that could be manufactured in large numbers. Combined cycle also offered low emissions and could be installed near load, still requiring transmission, but not nearly as much as purpose-built coal and nuclear baseload plants far from city centers. Capital costs were low, and as long as the price of natural gas was low as well, electric power could be cheap. Industrial users began lobbying states and Congress for access to this low cost power, outside the comparatively expensively regulated framework. In part with the model of FERC's Order 636 deregulating natural gas pipelines, Congress and FERC responded with the Energy Policy Act 1992, which established a class of "exempt wholesale generators" and FERC's landmark Orders 888, 889, and 2000 which helped establish competitive wholesale markets for power in the ISOs and RTOs which serve about two-thirds of the American public today.

On the state level in the 1990s, momentum grew for unbundling the generation, distribution, and transmission services historically offered by vertically integrated utilities and restructuring state markets into, theoretically, competitive retail services, regulated transmission and distribution (T&D) services and competitive wholesale markets for power. The political impetus for restructuring was linked to natural gas prices: the cheaper gas was, the more industrial users wanted "market power" as an alternative to regulated rates. By the late '90s the state struggle had come to Congress, and in the early 2000s terms like

“mandatory unbundling,” “participant funding,” and “stranded assets” were the battle cries of opposing interests. But with the California power crisis of 2000 and 2001, the state-level momentum for restructuring came to a halt, and after the failure of a proposed “Standard Market Design” at FERC, the Energy Policy Act (EPACT) of 2005 helped codify an uneasy status quo. About that time, too, companies like Enron and Mirant, which had seemed like unstoppable heralds of the future, went bankrupt, and Wall Street’s smaller echo of the dot-com boom in building gas-fired power plants came to a halt.

Combined-cycle gas installations peaked in the dot-com era.

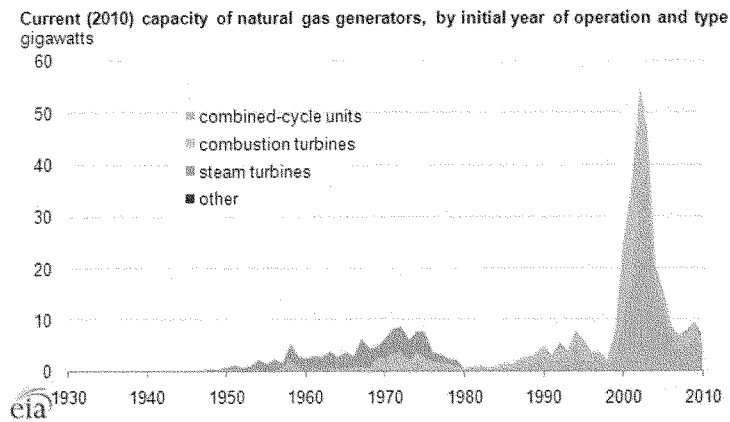


Image Source: Energy Information Administration (EIA), July 5, 2011, *Today in Energy*, <http://www.eia.gov/todayinenergy/detail.cfm?id=2070>

The seven major competitive markets in RTOs and ISOs did not stretch from coast to coast, as some envisioned, but where they were established they proved highly effective in making more efficient use of state generation portfolios and allowing regional planning for more efficiency gains. The nuclear renaissance of the 1990s and early 2000s is in large measure a success story made possible by competitive wholesale markets for power. However, just as cost-of-service regulation has an arguable bias toward “over-investment” (meaning investment levels higher than a pure free market might generate but possibly consistent with keeping jobs and revenue in state, as well as providing an extra margin of reliability that prudent state government officials might deem appropriate), the “scarcity-based pricing” used in the wholesale markets can have the opposite effect. The bias in such a pricing scheme drives prices down toward that of the lowest marginal cost provider, ultimately allowing no return on equity and in extreme cases, limiting prices to variable costs only. Such a scenario has been on display with the sudden and sustained drop in natural gas prices due to the shale revolution. Further, unless carefully designed,

constrained energy only-markets may fail to correctly value reliability and ancillary services, the economics of which are not necessarily reflected in an energy only price.

FERC and the major organized markets, led by the PJM RTO, have shown a solid decade's worth of attention to this problem. PJM and ISO-NE are both well along in establishing a "Pay for Performance" or "Capacity Performance" type construct which does provide enhanced economic support for reliability. FERC is also conducting an inquiry into price formation in the energy markets, which we regard as constructive. However, this alone does not address the problem of retiring baseload. In practice, capacity prices have failed to provide a signal for new investment in next generation baseload or the maintenance of existing, relatively high-cost baseload. In PJM for example, they provide a price for capacity for only one year, three years into the future. Accordingly, the markets are studying longer-term mechanisms as well, but progress is slow.

Even more fundamentally, a market based on scarcity pricing does not well-accommodate zero marginal cost resources, such as renewables, without driving down the clearing price for everything else. The classic case of this occurs when intermittent, variable wind resources with zero marginal cost and support from the wind power production tax credit appear on the dispatch curve prior to baseload nuclear, forcing the nuclear power plants to operate below capacity, and even, in effect, to cycle inefficiently for less revenue than they would have received in a market without the zero marginal cost supply.

Finally, the principle of economic dispatch in wholesale markets as currently structured is not consistent with the principle of environmental dispatch called for in the Clean Power Plan.

The practical uncertainty over the manner in which wholesale markets and market participants will weather the era of low prices and and accommodate not just renewables but energy efficiency and storage has hurt investor confidence and prevented an industry consensus from arising on what ideal competitive markets look like. Some speak of "Competitive Markets 2.0" in which there are separate procurements for energy efficiency, demand response, and the like. Others speak of regional "Super IRP" with procurement along the same lines. All the while, states continue to press for out-of-market solutions, as we see currently in Ohio, Maryland, and New Jersey.

Our main conclusion is that concern over utility or electric power business models is properly a concern for competitive wholesale suppliers. Regulated utilities do face competition for incremental power demand from renewables and other resources in a declining, flat, or slow growth environment, but their cost-based regulation gives them recourse to the rate base, and the Clean Power Plan offers the prospect--to some, at least--of increasing the rate base by investing in utility-scale renewables, new gas-fired power plants, cyber security, weather resiliency, and energy efficiency technologies. Regulated

utilities have been wrestling with the concept of rate decoupling for over 30 years, beginning with California's program in 1982. It is not inherently new.

The notion of intelligence and dispatchable power at the edge of the grid is not new either. In the 1990s and early 2000s, it meant diesel gen-sets and Capstone microturbines fueled by natural gas. But now distributed renewables and the promise of storage offer a way to make intermittent, variable, and occasionally off-peak power at zero marginal cost dispatchable as well. This raises many interesting questions about business models and pricing that can be answered only through market competition. End-to-end reintegration of the power industry seems highly unlikely at the moment, despite such technologies as Big Data, the Internet of Things, not to mention ubiquitous Internet Protocol-based sensors and controls that would make such re-integration possible. Rather the future seems more likely to be a mixture of regulated and competitive market participants in a diverse variety of forms.

From a historical perspective, we see a continuous search for the silver bullet, whether it be nuclear power so cheap it would not be metered, PURPA-style Qualified Facilities delivering power at "avoided cost" that turned out to be higher than other alternatives, full-blown unbundling, merchant transmission companies, or the latest new idea. Policy makers naturally look for the lowest cost, most expedient solution to meet immediate needs, even if, as with QFs, it does not represent a viable long term investment strategy. Similarly, rent-shifting or cross-subsidization from one industry to another is a recurrent theme, as Congress saw in past debates over participant funding, network upgrades, and socialized costs in the electric debates transmission of 15 years ago. Future market evolution will depend on reasonable cost allocation, accurate price discovery, and the principle that each new mode or technology, so much as possible, pay its own way in the competitive marketplace.

Reasonable policy principles for market driven evolution going forward might be as follows.

- Reliable and affordable electricity is of paramount value in the modern economy and an essential public service.
- Policy must incorporate a holistic, long-term view to support a diverse variety of options.
- Policy must be stable and predictable, in a framework open to market driven change
- Policy makers should avoid subsidizing any one technology, business model, or financing tool--with reasonable approaches to cost sharing and cost-allocation where appropriate.

- Policy makers should communicate clearly their commitment to viable wholesale markets and adequate returns on infrastructure investment.
- Policy makers should seek first to do no harm--since the consequences of errors can last for decades.

The CHAIRMAN. Thank you, sir.
Mr. Zindler, welcome.

**STATEMENT OF ETHAN ZINDLER, HEAD OF AMERICAS,
BLOOMBERG NEW ENERGY FINANCE**

Mr. ZINDLER. Good morning and thank you for this opportunity today. This is my first appearance before this panel under Chairman Murkowski's new leadership, so thank you. I appreciate the opportunity to contribute.

I'm here today in my role as an analyst with Bloomberg New Energy Finance, an energy market research division, a financial information provider, Bloomberg LP. Our group provides investors and others with data and insights on what we call new energy technologies. These include renewables such as wind and solar, electric vehicles, energy efficiency technologies, power storage such as batteries and natural gas, among others.

I would note that my remarks today represent my views alone, not the corporate positions at Bloomberg LP. They also do not represent specific investment advice and should not be construed as such.

I'd like to start by saying that these are, without a doubt, auspicious and exciting times for new energy technologies both globally and in the U.S. thanks to a confluence of economics and policy actions. I would argue that a fundamental rethink is now well underway about how energy gets produced, delivered, consumed and managed in many parts of the world, including the U.S.

In 2015 investment in these new energy sectors achieved an all-time high of \$329 billion globally. The volume of renewable energy capacity deployed into wind, solar and other similar power generating technologies also soared to a record globally.

What's notable is this build out of new projects is rising at a much quicker pace than is investment reflecting the fact that clean energy unit costs have dropped very dramatically.

In all the clean energy sector has received over \$1 trillion in new capital over the past four years and over \$2.5 trillion in the past decade. With approximately one half of all new capacity built worldwide in 2015 represented by renewables, it is fair to say that clean energy is no longer an alternative source but now very much in the mainstream.

What's behind this growth? Improved price competitiveness for these technologies and policy support from governments. It should be noted that the latter, policy actions, has certainly assisted in achieving the former, of lower clean energy prices.

Here in the U.S. we're seeing the power sector continue an unprecedented shift away from traditional higher CO₂ emitting sources of power generation. And in that regard, last year will likely be remembered as a watershed year for decarbonization.

Consider that in 2015 an annual record volume of coal-fired power generating capacity was either retired or converted to burn other fuels such as natural gas or biomass, a record volume of natural gas was burned in power plants and gas accounted for approximately a third of all U.S. power, about the same as coal, for the first time.

Solar photovoltaic capacity added hit an all-time high with a strong growth in both rooftop and utility scale subsectors. And U.S. clean energy investment totaled \$56 billion which was the most in four years and the second most ever.

Since 2007 the share of U.S. power provided by renewables including large hydro projects and natural gas and nuclear has surged from 49 percent to 65 percent with wind, gas and solar accounting for nearly all the new capacity that's been added. The net result is that CO2 emissions in 2015 fell to their lowest level since sometime in the 1990's from the power sector. Over the past eight-year average retail power prices in most markets remain roughly level while average wholesale prices have dropped.

Regarding energy efficiency, over the past five years U.S. demand for electricity and for all sources of energy has remained basically flat, even as the economy has grown. Efficiency improvements to homes, buildings and automobiles have all made contributions. As an aside, I would just note that many of these trends will be highlighted in an upcoming sustainable energy in America fact book which we'll be releasing in just a few weeks.

The achievements of the past year for clean energy came even as fossil fuel prices, most notably oil, but also gas and to a lesser extent, coal, were falling. At least thus far the impact on new energy technologies has been muted for a variety of reasons. The one area where lower oil prices did impact this sector was in the sale of hybrid electric vehicles which slipped in 2015. However, it should be noted that pure electric vehicle sales continued to rise and auto makers are now rolling out new, more affordably priced electric vehicles with longer ranges thanks to lower priced batteries.

Looking ahead the growth path for clean energy technologies appears wider and better to find than perhaps at any time. The so-called Paris agreement at the end of 2015 saw over 190 nations committing to reduced CO2 emissions. Here in the U.S. the EPA's Clean Power Plan has the potential to offer greater certainty for clean energy through the next decade. And finally, Congress' extension of key tax credits for wind and solar ensure solid short run growth for these technologies as well.

Just as importantly the playing field where clean energy technologies compete and beat their incumbent rivals in cost continues to expand thanks to technological innovation and economies of scale. While risks and potential obstacles still exist the outlook overall is generally positive for continuing growth and change.

Thank you again for this opportunity. I look forward to questions.

[The prepared statement of Mr. Zindler follows:]

**Testimony before the
Senate Committee on Energy and Natural Resources
Ethan Zindler
Head of Americas
Bloomberg New Energy Finance
January 19, 2016**

Good morning and thank you for this opportunity today. This is my first appearance before this panel under Chairman Murkowski's new leadership and I'm honored to contribute.

I am here today in my role as analyst at Bloomberg New Energy Finance, an energy market research division of financial information provider Bloomberg LP. Our group provides investors and others with data and insights on what we call new energy technologies. These include renewables such as wind and solar, electric vehicles, energy efficiency technologies, power storage such as batteries, and natural gas, among others.

I would note that my remarks today represent my views alone, not the corporate positions of Bloomberg LP. They also do not represent specific investment advice and should not be construed as such.

I would like start by saying that these are without doubt auspicious and exciting times for new energy technologies both globally and in the US, thanks to a confluence of economics and policy actions. I would argue that a fundamental re-think is now well underway about how energy gets produced, delivered, consumed, and managed in many parts of the world, including the US.

In 2015, investment in these new energy sectors achieved an all-time high of \$329bn. The volume of renewable energy capacity deployed -- into wind, solar, and

other similar power-generating projects -- also soared to a record globally. What's notable is that this build-out of new projects is rising at a much quicker pace than is investment, reflecting the fact that clean energy unit costs have dropped dramatically.

In all, the clean energy sector has received over \$1trillion in new capital over the past four years and over \$2.5trillion in the past decade. With approximately one half of all new capacity built worldwide in 2015 represented by renewables, it is fair to say that clean energy is no longer an "alternative" source, but now very much in the mainstream.

What's behind this growth: improved price competitiveness for these technologies and policy support from governments. It should be noted that the latter -- policy actions -- has certainly assisted in helping achieve the former, lower clean energy prices.

Here in the US, we are seeing the power sector continue an unprecedented shift away from traditional, higher CO2 emitting sources of power generation. And in that regard, last year will likely be remembered as a watershed for "de-carbonization." Consider that in 2015...

- An annual record volume of coal-fired power generating capacity either was retired or converted to burn other fuels such as natural gas or biomass.
- A record volume of natural gas was burned in power plants and gas accounted for approximately 1/3 of all US power -- about the same as coal for the first time.
- Solar photovoltaic capacity added hit an all-time high, with strong growth in both the rooftop- and utility-scale sub-sectors.
- US clean energy investment totalled \$56bn, the most in four years and the 2nd

most ever.

Since 2007, the share of US power provided by renewables (including hydro), natural gas and nuclear has surged from 49% to 65% with wind, gas, and solar accounting for nearly all new capacity added. The net result is that CO2 emissions in 2015 fell to their lowest level since some time in the 1990s. Over the past eight years, average retail power prices in most markets remained roughly level while average wholesale prices dropped.

Regarding US energy efficiency, over the past five years, US demand for electricity and for all sources of energy has remained basically flat, even as the economy has grown. Efficiency improvements to homes, buildings, and automobiles have all made contributions. As an aside, I would note that all of these trends are highlighted in an upcoming 2016 Sustainable Energy in America Factbook to be released in a few weeks.

The achievements of the past year for clean energy came even as fossil fuel prices -- most notably oil, but also gas and to a lesser extent coal -- were falling. At least thus far, the impact on new energy technologies has been muted, for a variety of reasons.

The one area where lower oil prices did impact this sector was in the sale of hybrid-electric vehicles, which slipped in 2015. However, it should be noted that pure electric vehicle sales continued to rise and automakers are now rolling out new, more affordably priced electric vehicles with longer ranges thanks to lower-priced batteries.

Looking ahead, the growth path for clean energy technologies appears to be wider and better defined than perhaps at any time. The so-called Paris agreement at

the end of 2015 saw over 190 nations committing to reduce CO2 emissions. Here in the US, the EPA's Clean Power Plan has the potential to offer greater certainty for clean energy through the next decade. Finally, Congress's extension of key tax credits for wind and solar ensured solid short-run growth for those technologies.

Just as importantly, the playing field where clean energy technologies compete and beat their incumbent rivals on cost continues to expand thanks to technological innovation and economies of scale. While risks and potential obstacles still exist, the outlook overall is generally positive for continuing growth and change.

Thank you again for this opportunity. I look forward to your questions.

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The CHAIRMAN. Thank you, Mr. Zindler.
Mr. McGroarty?

**STATEMENT OF DANIEL MCGROARTY, PRINCIPAL, CARMOT
STRATEGIC GROUP INC.**

Mr. MCGROARTY. Thank you.

My thanks to the Committee for the opportunity to testify this morning. I'm Dan McGroarty, Principal of Carmot Strategic Group, an issues management firm based here in Washington, DC. Strategic resources are a core element to my practice.

My advisory companies include Texas Rare Earth Resources, Graphite One, American Manganese, Denham Capital Management, and Rio Tinto, companies that are working to develop new sources of metals ranging from copper and graphite to manganese and rare earths. I also consult to the Institute for Defense Analyses which supports the Departments of Defense and Homeland Security, the Joint Chiefs and Intelligence community, on issues related to strategic materials and resource security. That said, the views I express today are my own.

The Committee asked the single question as the entry point into today's hearing and that's where I will start. The near-term outlook for the commodity markets can be summed up in a single word, bleak.

We've heard this morning about the collapse in price of oil. The same is generally true for hard rock commodity prices. Look at five key industrial minerals, aluminum, copper, lead, nickel and zinc. In the past five years aluminum is down 36 percent, lead 35, zinc down 40, copper down 55, nickel down 64.

Of course it's not as if commodity cycles are novel, they happen. That's Econ 101. The market is self-corrective, and in the long run that is true. What's also true, as Keynes put it, that in the long run we are all dead.

I can't answer the question how long is the long run. What I can discuss is what risks we run now and in the near-term while we wait for the long run to arrive. Those risks are real.

When it comes to critical metals the United States is deeply dependent and growing more so. The U.S. Geological Survey has just released a useful historical snapshot. 30 years ago the U.S. was 100 percent foreign dependent for 11 metals and minerals. Today the U.S. is 100 import dependent for 19 metals and more than 50 percent dependent for 47 minerals, nearly half of the naturally occurring elements on the periodic table.

This dependency has serious implications for national security. In the most recent defense stockpile report of the 12 materials the Pentagon recommends for stockpiling, China is a significant supplier of all 12.

We are in the midst of a material science revolution and access to the so-called minor metals is taking on major implications. Unfortunately, in many cases U.S. dependency is severe, even complete.

Consider clean energy. Graphite is key to EV batteries and energy storage. The United States produces zero natural graphite. We're 100 percent import dependent. Indium is needed for flat screen TVs and solar panels. We produce zero indium. Thin film

solar panels are made of CIGS materials, copper, indium, gallium, selenium. We have a 600,000 metric ton copper gap at present and selenium is recovered from copper processing. Gallium comes from aluminum processing. We are 99 percent import dependent.

The list is long. We need radium for high strength alloys on fighter jets like the F35. Radium is dependent on copper processing, and we're 83 percent import dependent.

We need rare earths in too many applications to list. Wind turbines, lasers for medical and national security applications, smart phones, smart bombs. We produce zero rare earths. We're once again 100 percent dependent on China. In the effort to reverse our resource dependency the American Minerals Security Act is a strong step in the right direction.

In the Executive Branch productive work is being done at the Defense Logistics Agency to address strategic metal's needs and Critical Materials Institute at DOE. And at the White House the materials, the White House's Materials Genome Initiative which aims at supporting and I quote, "U.S. efforts to discover, manufacture and deploy advanced materials twice as fast at a fraction of the cost." That's a laudable goal but it's going to prove difficult for American innovators to be twice as fast when America's mine permitting process is twice as slow as in many other mining nations.

We could also do more to encourage recycling of rare metals from scrap laptops and cell phones, so-called urban mining. And we should continue efforts to find substitutes to rare metals. But we must recognize that the search for substitutes may simply swap our dependency on one scarce material for another equally or even more scarce.

That's why I'm a subscriber to the all of the above school. Let's recycle and seek substitutes, but let's also recognize there's no way out of our dependency without added production.

Going back to that commodity cycle. Pricing will come back. Remember the long run. But if the U.S. allows the trends making the long permitting process even longer, production of key metals is going to take place elsewhere and the manufacturing we want to see right here in America will be pulled where the metals are.

I'll close with a comment and a question. I don't think there's another nation in the world that can match American ingenuity. We can pioneer the ideas behind wind and solar, we can design ever more powerful technologies for our war fighters, but where will the materials that make these new applications real come from?

I thank the Committee for this opportunity to testify, and I look forward to your questions.

[The prepared statement of Mr. McGroarty follows:]

Senate Committee on Energy and Natural Resources

Hearing

to Examine the Near-Term Outlook for Energy and Commodities Markets

366 Dirksen Senate Office Building

10:00 a.m.

January 19, 2016

Written Testimony of

Daniel McGroarty
Principal,
Carmot Strategic Group Inc.

My thanks to the Committee Chair, Senator Murkowski, and to Ranking Member Senator Cantwell for the opportunity to appear here this morning. My name is Daniel McGroarty. I am principal of Carmot Strategic Group, an issues-management firm based here in Washington, D.C. Strategic resource issues are a core element in my practice.

As is disclosed in my biographical material, my advisory companies include Texas Rare Earth Resources, Graphite One, American Manganese, Denham Capital Management and Rio Tinto – companies that are working to develop new sources of metals ranging from copper and graphite to manganese and rare earths – plus co-production of other metals and minerals key to new technology applications in markets where we want to see America rebuild its economic strength. I also run the American Resources Policy Network, a virtual think tank that encompasses all aspects of domestic non-fuel resource production – and I consult to the Institute for Defense Analyses (IDA), which supports the Departments of Defense and Homeland Security, the Joint Chiefs' Joint Staff and the Intelligence Community on issues related to strategic materials and resource security. I want to underline, however, that the views I express today are my own.

The Committee asks a single question as the entry-point into today's hearing, and that is where I will start. The near-term outlook for the commodity markets – and, for related reasons I will explain, for the alternative energy markets – can be summed up in a single word: bleak.

As the Committee has heard this morning, oil and gas prices are in sharp decline, and each day's headlines seem to bring stories of new lows. The same is generally true for hard-rock commodity prices. Look at prices for five key industrial minerals – aluminum, copper, lead, nickel and zinc. In the past 5 years, aluminum is down 36%, lead 35%, zinc is down 40%, copper 55% and nickel 64%.

Of course, it's not as if commodities cycles are novel – they happen. Growth rates slow, supply exceeds demand, prices fall, producers idle their mines, postpone new projects and abandon exploration. Then, the economy works through the surplus production, demand returns, supply tightens – prices rise – and so does the incentive for investment in new exploration and development. It's a familiar cycle – Econ 101.

The market is self-corrective, and in the long-run, that is true.

It is also true, as Keynes put it, that “in the long-run we are all dead.”

I can't answer the question – “how long is the long-run?” -- until commodities prices recover. What I think may be of interest to this Committee is what risks we run -- now and in the near-term -- while we wait for that long-run to arrive.

And the risks are real – with implications for the strength of the American economic recovery, for the revival of U.S. manufacturing might, and for the hoped-for dominance of U.S. ingenuity and enterprise in the advanced technology applications that we know are shaping the world of the 21st Century.

Put simply, in the case of critical metals and minerals, the U.S. is deeply dependent – and growing more so. The US Geological Survey has just released a very useful historical snapshot. 30 years ago, the U.S. was 100% foreign-dependent for 11 metals and minerals. Today, the U.S. is 100% dependent on foreign supply for 19 metals and minerals, and more than 50% dependent for 47 minerals in all – nearly half of the naturally-occurring elements on the Periodic Table.

There are national security implications to this dependency as well. In the most recent National Defense Stockpile Requirements Report delivered to the House and Senate Armed Services Committees, of the 12 materials with identified shortfalls that

the Pentagon report recommends for stockpiling, China is a significant supplier of all 12.

In the real world, much of our access to key minerals is as by-products or co-products of the industrial minerals. Take the five I mentioned earlier – aluminum, copper, lead, nickel and zinc. Taken together, those 5 “unlock” our access to an additional 25 elements on the Periodic Table. Nearly all of them are used in today’s advanced technology applications.

We used to call them “minor metals.” But we are in the midst of a materials science revolution – and access to the minor metals is taking on major implications.

Unfortunately, in many cases, U.S. dependency is severe -- and even complete.

Take the materials we need for clean energy. Graphite is key to EV batteries and energy storage. The U.S. produces zero natural graphite – we are 100% import dependent.

Indium is needed for flat-screen TVs and solar photovoltaic panels. Most indium is derived from zinc mining – the U.S. is 81% import-dependent for the zinc we use, and we produce zero indium.

Thin-film solar panels are made of C-I-G-S materials – those letters stand for Copper, Indium, Gallium and Selenium. We have a 600,000 metric ton copper gap at present – demand exceeding supply. Selenium is recovered from copper processing.

Gallium comes from aluminum processing – we are 99% import-dependent – and we are closing American aluminum smelters at a record pace.

The list is long. We need rhenium for a high-strength alloy in the jet turbines on the F-35 and other fighter aircraft. Rhenium is dependent on copper processing – and we are 83% import-dependent. Congress has directed the Defense Department to purchase electrolytic manganese, used in key super-alloys, for the stockpile – the U.S. produces zero manganese. We need rare earths in too many applications to list: Wind turbines, lasers for medical and national security applications, smart phones and smart bombs. We produce zero rare earths – and we are once again 100% dependent on China.

In terms of beginning the work to reverse our resource dependency, Senator Murkowski’s American Mineral Security Act is a strong step in the right direction. As I understand today’s hearing, we’re not evaluating policy and programs. But there are

executive branch efforts that merit mentioning: Work at the Defense Logistics Agency to recast the defense stockpile in ways that suit our new world of materials science... The Critical Materials Institute under the aegis of Department of Energy...

And then there is the White House's Materials Genome Initiative – which aims at supporting “U.S. institutions in the effort to discover, manufacture, and deploy advanced materials twice as fast, at a fraction of the cost.” That's a laudable goal – but it's going to prove difficult for American innovators to be twice as fast when America's mine permitting process is twice as slow as in other mining nations.

We can also do more to encourage recycling of rare metals – reclamation from scrap laptops and cellphones – so-called urban mining – and also from fly ash and mining waste piles of all types where techniques employed 50 and 100 years ago left behind metals and minerals no one needed then, but which are critical now. This is win-win – for the economy and the environment: Our aim should be to recover valuable metals – even as we remediate old mine wastes.

And we should continue efforts to find substitutes to rare metals – but we must do so mindful of the fact that some of today's scarce minerals and metals are themselves substitutes for scarce metals from earlier decades. Our dependency is so severe that we must also realize that the search for substitutes may simply swap our dependency on one scarce metal for another metal, equally or even more scarce. For instance, there are known substitutes for rhenium, where our import dependency is 83%, in some catalyst applications – but those substitutes include gallium (99% dependency), germanium (95%), or indium and vanadium (both 100%).

This is why, when it comes to remedying U.S. resource dependency, I'm a subscriber to the “all of the above” school – let's recycle, reclaim and seek substitutes, but let's also recognize there is no way out of our dependency without added production.

Going back to commodity cycles -- pricing will come back. Remember the long-run. But if the U.S. allows the trend-line towards decreased exploration spending and increased time to complete permitting to continue – production of key metals and minerals is going to take place elsewhere. And the manufacturing we want to see right here in America – will be pulled to where the metals are.

I don't think there's another nation in the world that can match American ingenuity. We can pioneer the ideas behind wind and solar and so much else – but where will the materials that make these new energy sources real – where will they come from?

How we answer that question will determine to a large extent whether the U.S. can regain its manufacturing might... Whether America will lead the alternative energy revolution... And whether the U.S. will have the metals and minerals we need to provide the modern military technology we depend on.

I thank the Committee for this opportunity to speak today, and I look forward to your questions.

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The CHAIRMAN. Thank you, Mr. McGroarty.

I think it is so important to the conversation that we be discussing minerals and those commodities. I think far too often we get focused on the vulnerability we have had historically when it comes to reliance on others for oil. That is understood. People know about that, but they fail to make that connect when we are talking about the need for our minerals and what it is that we use them for. So I look forward to that discussion with you.

I want to ask the question that I think is on everyone's mind here today. As we have seen over the weekend the implementation day with the agreement with Iran. The fact that the sanctions that have been put in place on oil coming out of Iran have now been lifted, that those reserves that were sitting in tankers offshore are now able to go out and find customers.

You have suggested, Mr. Sieminski, that in '16 we should anticipate about 300,000 barrels coming out of Iran into the global oil market by '17 an additional 500,000.

Mr. SIEMINSKI. Additional, right.

The CHAIRMAN. That is what I would like to ask you about because there have been suggestions that what we will see ultimately is in the range of a million barrels a day coming from Iran. When you look to the longer term and what is happening with the response today from Iran getting their oil out on the market, the impact to the global market and to the price of oil, the fact that we already have a glut of oil out on the market, what does that mean for the short-term pricing of oil?

You have indicated your estimate is somewhere between 40 and 50 between year 2016 and 2017. Can you give me more certainty going beyond '17 in terms of what Iran does to the market?

Also if you can, and I will ask you, Mr. Halff, to join this conversation, discuss the situation in Venezuela and the fact that you have indicated that we cannot ignore Venezuela in this discussion as we are looking at the international picture on production. So if we can have this conversation, Iran, Venezuela and just for good measure we can throw in Saudi Arabia here.

Mr. Sieminski, if you want to start.

Mr. SIEMINSKI. Senator, Iran had been producing about 2.8 million barrels a day of crude oil and other liquids. So we think that that could hit 3.3 million barrels a day by the end of 2016. So these numbers move around a lot. It depends on how much comes out of storage and how much comes out of production, and I'll come back to that in a second.

And then we thought that the number could hit 3.7 million barrels a day by the end of 2017. So that's a little less than a million, but it's close to that million barrel a day growth number from where they are now to where they would be at the end of 2017. The annual averages would be a little bit different because the trend is up so the annual averages are going to be a little bit lower.

In thinking about Iran there are two aspects to this. They have between 30 and 50 million barrels of floating storage in tankers that could come onto the market fairly quickly. But a lot of that is believed to be condensates. So it's a very light kind of crude oil, and the markets for that are mostly in the chemicals business and

a lot of it was probably destined for China. And we'll just have to see how that works into the estimates for China's economic growth.

The second aspect is how quickly production can actually grow. And that may depend on how rapidly foreign investment is allowed to come into Iran to help them rebuild their oil fields. And that could be a bit slow too. So there are a lot of uncertainties in this.

And then layering on something that Antoine mentioned earlier, this relationship between Saudi Arabia and Iraq and Iran is very important. Iran is one of the three big players along with those other two countries in the Gulf area, and how each of those countries puts their volumes of crude oil on the market has a lot to do with where prices end up. And so there's probably going to be a lot of back and forth between those three countries.

So I think we're back to that observation that says that the uncertainty in crude oil prices as we look out over the next year too, is very high.

The CHAIRMAN. Greater volatility.

Mr. Halff?

Mr. HALFF. Yes, I agree totally.

I think for Iran the question is—there are four questions that we have to consider. The first one is how much can they produce now? The second one is how much are they willing to produce now? The third is how much is the market capable of absorbing now from Iran? And the fourth is how much is the long-term production capacity or the capacity to increase production in the longer term?

The bottom line is nobody knows exactly how much they can produce today. We tried to look at it when I was working at the International Energy Institute looking at the testimony from people who've had access to the fields there. Our perception was that Iran had managed to repair some of the damage that had been caused under the previous President, Ahmadinejad, and it had the capacity to increase production fairly rapidly, almost instantly, by somewhere between 500,000 and 800,000 barrels per day.

The question is for Iran. How much is it willing to sell given its price appetite? It's always been a hoggish member of OPEC. Since the early days of the Iranian revolution it's always taken the view that the west of the market should pay more for oil and that that oil is worth more than the market is paying for it.

So not surprisingly I think Iranian dealers have made contradictory statements over the last few months that said they wanted to ramp up production immediately but they've also said they don't want to crash the market. They don't want to flood the market too quickly with too much oil and cause the price to fall even further.

So the main question is how much the market can take? And I don't think it can take more than a few hundred thousand initially, two, three, maybe four hundred. And it's going to be a gradual ramp up for Iran to regain its market share.

Now the capacity to increase production over the longer term that would depend on the willingness of investors to go back, the terms offered and that's much more questionable, much more longer term.

The CHAIRMAN. Please, go ahead because I asked about Venezuela. We have not heard that yet.

Mr. HALFF. Venezuela is struggling. Its production capacity has been degrading over the years. Production volumes have been falling. It's managed to produce as much as it can, but its revenue has been doubly hit by the drop in volumes and the drop in prices. And it can sustain its production.

Now based on the national oil company is asking for its foreign partners to pay for the light liquids or the condensates or enough of the import to blend the heavy crude to export it. The partners are not willing to do that. It's going downhill, and the social outlook, the social stability outlook is also looking very bleak.

Now the question there is whether social turmoil could actually be, cause production to fall or to be disrupted as had been the case in 2002–2003 during the general strike there. And my view is that capacity is probably more insulated now from social turmoil than it had been at the time. But the outlook and the capacity to sustain production looks very, very dismal.

The CHAIRMAN. Thank you for your comments.

You know, this whole discussion about Iran is just so galling as a representative from a state that has enormous potential. We will, as a country, tell Iran go ahead, produce more while at the same time we are going to continue locking up our potential for further oil exploration and production whether it is on ANWR or whether it is our potential for offshore.

So know that this is going to be a year where you are going to continue to hear me not complaining but being very discouraged and really quite angry at the way we have chosen to advance a policy when it comes to greater reliance on people, nations, that have not been good actors and yet continuing sanctions on ourselves which is what we are doing with certainly Alaska production.

Senator Cantwell?

Senator CANTWELL. Thank you, Madam Chair.

I want to, again, thank all the witnesses. When I think of your collective wisdom here of covering energy markets over your careers. It certainly must be an interesting time to now have your expertise asked for because certainly we are on a roller coaster of sorts. I am sure that it has been very interesting.

I think for me you just have to understand I come from a hydro state where cheap electricity has rebuilt our economy over and over and over and over again. I appreciate not only it is not without some environmental cost, there clearly have been, but the efficiency which I think is the *nom de jour* in the context of where we are as a country, efficiency in every business model. Efficiency is going to continue to drive the energy sector as well. That is why so many people are interested in distributed generation because distributed generation, being closer to the source, automatically cuts out a big part of cost.

So I wanted to ask you, Mr. Zindler—the years brought a significant shift in generating cost comparison between renewable energy and fossil fuels that is by Bloomberg New Energy Finance. Can you talk about how you see these trends moving forward and whether they will continue to compete based on price? And how do you see solar and battery technology and their trajectories in continuing to lower costs?

Mr. ZINDLER. Sure. So thanks for that question.

Well, I mean, look, the first thing to note about renewables and I think I hope I made this point in my comments, is that they are increasingly cost competitive. They're not cost competitive everywhere. And essentially the playing field in which this competition is taking place is growing virtually every day.

And so, obviously the place where renewables are most competitive are in places where you have excellent natural resources and/or very high incumbent power prices. So they can compete against the incumbents and potentially win.

So the places where we're seeing, let's say, wind most competitive often are in the center of the country, particularly in Oklahoma and parts of Texas, but also Iowa and Minnesota and elsewhere where you have some extraordinary winds. That combined with the fact that we are seeing bigger and more effective wind turbines that are being deployed that essentially can scoop up more of the wind and generate more power is making wind more competitive all the time.

On the solar side the costs have been dropping, as you noted in your comments as well, quite rapidly. We don't see quite the same level of decline over the next couple years. Although we do see it declines longer term.

And as you note quite rightly that when you're competing at the local level solar can be best positioned. In other words, as I'm sure you know, electricity is priced on a wholesale basis and then it's priced at a retail basis. And on a retail basis those prices are much higher.

So inevitably solar can be much more competitive at a retail level, so-called behind the meter, because you just have to offset the price that the homeowner or the business owner is paying, the final price for electricity that they're paying which includes the distribution cost of getting it there. So, you know, those costs in the regions where this is taking place is expanding all the time.

I would say this, that looking forward a big part of thinking about how competitive renewables will be, will be contingent on the price of natural gas. Gas is increasingly the price setter in the market. And gas trading at \$2 per million BTU today, I think Adam was saying that they're forecasting up to \$3 in the next several years. We do forecasting as well. It's probably in about the same ballpark.

But so long as gas prices, you know, stay relatively low they'll be strong competition between those technologies. If gas prices zoom back up then we think renewables are extremely well positioned. But overall we think renewable costs continue to slope downward, not at the same accelerated pace we've seen recently but more gently going forward.

Senator CANTWELL. But if you were going to describe this inning of the ball game in reducing costs, we are probably just in the first or second inning.

Mr. ZINDLER. Yes, we're somewhere in, I don't know, maybe the third or fourth. But, I mean, it's starting, you know, everyone thinks that one day we'll wake up and suddenly, wow, clean energy is cheaper than fossil energy. And it doesn't work like that, you know. It's a great, big, complicated world. And over time in different places we're seeing more and more of this take place.

Last quickly just on storage and you did ask about that and I didn't answer. Similar, sort of, economics where power storage starts to make the most sense on the distributed behind the meter level at first because you're helping to offset the cost of retail power. And in some cases you're helping to offset if you have to pay surge pricing or you know, particularly high pricing or any kind of, you know, fees related to your excessive use of power. If you can offset that with power storage you're in good shape.

So that's where we'll probably see some of this stuff come into the money first but there's been a lot of developments around utility scale power storage taking place as well and battery prices are—have been dropping. We anticipate will continue to drop as more capacity comes online.

Senator CANTWELL. On that point I want to keep making more investment because when I look at where this discussion has gone about oil and I remember Mr. Tollerson was before the Finance Committee a few years ago. I asked him what the price was just on the development. He was a very forthright, and he basically said \$60 a barrel.

So if we're at \$30 today and \$60 is the recovery cost, it seems to me that yes, as Mr. Halff said, there's going to be a correction at some point in time. I am not hoping to go back to \$60 a barrel oil though. I want to diversify and make sure that we have a smoother path toward this transition.

So thank you for that.

The CHAIRMAN. Senator Cassidy?

Senator CASSIDY. Thank you.

First, I think I heard Senator Cantwell mention that and I think I heard this, Senator Cantwell, that either wind or solar now provides more jobs than those which are in oil and gas? If that is what you said, maybe I misheard. That is not true.

Just to point out the Bureau of Labor statistics points out that their direct employment under oil and gas is about 1.6 million jobs, 1.86 million, and renewable jobs related to all renewable jobs in the United States is 724,000. And there is a greater differential if you include the indirect. Just to mention.

Mr. Zindler, in your testimony you speak about how renewables now account for 67 percent of energy production but you include natural gas as a renewable. Is that in your kind of list of those which account for that 67 percent, was that a misprint or ?

Mr. ZINDLER. I think I said if you include renewables with a definition including large hydro, if you include nuclear and you include natural gas. Those are not, those are different categories.

Senator CASSIDY. Okay. So under renewables, you are lumping in natural or put it this way, in that statement, renewables plus natural gas.

Mr. ZINDLER. That may have been what I said, but I think what I wrote was I described these as different categories and that was my intention.

Senator CASSIDY. I will look at that again. I think I read differently but will not dwell upon it.

Mr. Halff, I really enjoyed your testimony. I have enjoyed it all, but I never understood the perspective of the Saudis as well until

I read your testimony. So, thank you for that. Let me ask a couple questions on that.

You had mentioned that imports of light oil into the United States are increasing. Why is that if we have all this surplus light oil in the United States?

Mr. HALFF. So that's a function of the—thank you for the question. It's a function of the differential between U.S. prices and European prices.

Senator CASSIDY. But I presume that our Louisiana light sweet and West Texas intermediate is priced now similar to Brent but yet the transportation cost has to be less here. I mean, obviously, you are shipping it from Louisiana into a Gulf Coast refinery, so it seems that that would be a price advantage for a domestic producer.

Mr. HALFF. But that's the trick about U.S. transportation of crude oil within the U.S. It has to be done with Jones Act vessels or by rail and that's—

Senator CASSIDY. Or by pipeline off the Louisiana coast.

Mr. HALFF. Right. But there's only so much that can be moved by pipeline from east to west.

Senator CASSIDY. Okay.

Mr. HALFF. And to the markets where the imports of light crude have been coming in.

Senator CASSIDY. I am still not quite sure I'm, just because it even seems like most of the Louisiana, most of the West Texas intermediate is coming by pipeline. I am still not sure the impact of the Jones Act deployment. I can see if you are moving from Louisiana to Philadelphia but since most of our refining capacities are on the Gulf Coast I am still not sure unless you are saying that we are importing the light oil into Philadelphia.

Mr. HALFF. Yes. My understanding is the imports of light crude, light sweet crude, tend to go to the East Coast.

Senator CASSIDY. Gotcha.

Mr. HALFF. Of the U.S.

Senator CASSIDY. Gotcha.

Next, Mr. Sieminski, this is not related to your testimony but it is something you are probably familiar with. The EIA has projected decreased energy consumption relative to baselines a little bit ago. So if there is a baseline five years ago your predicted energy consumption would be here. Your more recent forecast has energy consumption there.

There is a tight correlation statistically, and it is reflected in EIA's data as well between economic growth and energy consumption. Is it fair to say that EIA has decreased its forecast for the amount of energy consumed, electricity consumed, because you forecast less economic growth?

Mr. SIEMINSKI. Our economic growth forecasts have come down slightly over the past few years, but I think that's just a reflection of some of the overall economic conditions and not just in the United States, but globally. To say that the ratios of energy consumption to GDP generally have been improving because of efficiency gains and some structural changes in the economy. So as you move from high energy consuming industrial activities to service sector, consumption goes down.

Senator CASSIDY. So maybe facts from energy intensive enterprises, if you will, offshore to China and what is left are service related jobs. If I may kind of, interpret that. And so you end up using less when your GDP is down but also you use electricity in a service job relative to energy intensive industry.

Mr. SIEMINSKI. I think these gains and efficiencies are taking place around the world including in China. But—

Senator CASSIDY. Now I have read though, if I may, that actually in times past when efficiencies have increased the amount of electricity used has likewise increased because the cost input, if you will, is now lower and so therefore folks are able to ramp up production because the cost input is lower.

Mr. SIEMINSKI. When EIA has done our long-term projections in our annual energy outlooks on the electricity side, I do know that a lot of the improvements are in efficiency. That's reduced use in households, for example, because of improved efficiency of lighting, improvements in the efficiency of big energy using equipment.

Senator CASSIDY. I am sorry, I am way over. Hopefully there will be a second round, so I will come back to that.

Thank you.

Mr. SIEMINSKI. Happy to do that, Senator.

The CHAIRMAN. Okay.

Senator Hoeven?

Senator HOEVEN. Thank you, Madam Chairman.

Alaskan water which is very nice.

The CHAIRMAN. Alaskan glacier water.

Senator HOEVEN. Right, yes. That is great. Thank you.

I would like to thank all the witnesses.

We have an Administration, the Obama Administration, that continually makes it harder and more expensive and more difficult to produce oil and gas in this country through regulation and other restrictions while at the same time making it easier for our adversaries to produce and export oil and gas.

An example is recently lifting sanctions on Iran. That is actually borne out in your projections. I think both Mr. Sieminski, Mr. Halff and maybe others just got done informing us that U.S. domestic production will decline by approximately 600,000 barrels a day over the next several years and that Iran production and export will increase by 800,000 barrels a day over 2016 and 2017.

I think that is the wrong approach, and I think it has ramifications in job creation in this country, in economic growth in this country and in national security from the standpoint of energy security.

So my question to you, and I would like to start with Mr. Sieminski and Mr. Halff. I appreciate both of your testimony very much. I might ask Mr. Halff also to put in some projection in terms of what he anticipates for price over 2016 and 2017 as Mr. Sieminski did.

Others can respond to this as well, but I would like you to give me your recommendations as to what we should do from a public policy standpoint so that our industry can better compete in this global economy. As we look at energy legislation, I know Senator Murkowski and Senator Cantwell have energy legislation they hope to bring to the floor, possibly even this week. What type of

provisions should we advance to help our industry compete? I would like to start with Mr. Sieminski.

Mr. SIEMINSKI. Senator, I think I'll let Antoine talk about policy recommendations since EIA generally tends to stay away from those. And if I want to keep my job I should as well. [Laughter.]

Mr. SIEMINSKI. On the question of what has been the main factor driving oil production down, I would say it's the price. So I don't think it was a policy decision that caused oil production to climb.

Senator HOEVEN. That was not my question.

Mr. SIEMINSKI. Right.

Senator HOEVEN. My question is how do we empower our industry to compete rather than shackle it at the same time we are actually taking steps that assist our adversaries? That was my question.

Mr. SIEMINSKI. Right.

Well, one thing that Congress and the Administration did in a bipartisan fashion was to agree to allow crude oil exports. So that would be one answer to your question. I think that allows for U.S. crude oil production to compete on global markets.

The thing that's, kind of, limiting the impact that that would have in the near-term is that the Brent and WTI prices are very close together. And so the advantage that our crudes had on global markets is somewhat limited.

Senator HOEVEN. I agree.

Lifting the oil export ban was very important and that set a very good example of what I am talking about. What else can we do that can make a difference, again, empowering our industry to compete? If you do not want to make recommendations, I understand. But then I would like to go to Mr. Halff. But that is specific to what I want. What can we do that helps our industry compete which benefits our nation? That is what I am looking for.

Mr. SIEMINSKI. I don't know whether it's necessarily a government function, Senator, but I think one of the big advantages that U.S. industry has had and is likely to continue to have is the technology, the technology of shale oil development occurred here and maintaining the improvements in costs of drilling and production is something that would make a big, positive difference for our producers.

Senator HOEVEN. Mr. Halff, do you have recommendations as to how we can help our industry better compete in this global competition, this global economy?

Mr. HALFF. I wish I had but I think it's actually doing a pretty good job competing. And I would agree that the lifting of the export restrictions is a very positive step because it allows oil to go where it's needed in the market and that the U.S. can compete in that. It's opening up new markets, potentially, if the financials support exporting. So that's a very good step.

Another thing which I think is very good for competition is what Adam Sieminski has been doing at the EIA which is improving data transparency. The more the market knows about how the industry is doing, where the stocks are going, what are the trends in production and demand, the more investors are capable of providing the right response to making the right moves and helping the industry compete.

But I think it's a very new world for the oil industry, you know, for most of its history oil companies have operated under some kind of price umbrella whether under the Rockefeller standard oil system or the Seven Sisters Texas Railroad Commission or OPEC. There was always some kind of protection against the fluctuations in prices that was provided to industry and enabled it to make a large, long term investments.

Now, that umbrella has disappeared. It's gone. OPEC is out of the picture for now. It could come back later but it's out right now, and industry has to learn to live in a very different world.

This is a process that will plan its course naturally. But my projections are that once the rebalancing of the market runs its course and the market starts recovering the U.S. industry would be in pretty good shape.

I don't think that the oil companies in the U.S. would be the largest, the main victims of the price correction. OPEC, I think, will come out pretty good. GCC countries, I mean, Saudi Arabia, Kuwait, UAE and U.S. companies, I think, would come out on top.

The bigger victims of the downturn would be the very heavy, big ticket projects, deep water, West Africa, all the very high investment intensive projects. Those would likely be more affected by the downturn in my view.

Senator HOEVEN. Any other recommendations, specifically, that help us compete? Alright, thank you.

The CHAIRMAN. Thank you, Senator Hoeven.

These are very important questions in terms of where these forecasts place the United States and our domestic production, what it means for our economy, what it means for our jobs and what it means for prices for the American consumer.

It has been a tough, tough 18 months or so in Alaska. We have seen Shell, obviously, lay off almost all of their folks up north. Conoco has had major layoffs. BP just announced last week major layoffs in the state. Repsol canceled a winter project which meant contractors not moving forward with projects. Statoil returned their leases in the offshore. It has been a very, very discouraging time.

Low prices in Alaska do not necessarily translate to good news. Our treasury is certainly hurting as a state that is very reliant on oil. But as I mentioned, low prices for the consumers do not necessarily line up with what you are seeing in the lower 48.

I mentioned the prices in Nome. I tried to get a better read on what they were actually. In October they were hanging at \$6.22. When I was there in January, they had dropped to about \$5.50 a gallon.

The clips this weekend have gasoline at \$9.99 in Noatak, and they are trying to work with the Park Service to be able to haul some fuel across Park Service lands. I do not know whether we are going to be able to do that, but by gosh I am sure going to try because nobody should be paying \$9.99 for their oil when people here in Washington, DC are getting it for \$2.10 or whatever it is here.

So there is a great deal of inequity, and that is what gets my dander up and gets my ire up. When I look to the opportunities that we have now created for Iran that we are not creating, that we are not allowing, for Alaska or other states like North Dakota or Louisiana, it should get us riled up.

I recognize that so much of this is about price, but it is also about the policies that we put in place and making sure that you have an environment that is constructive. This is where I want to talk a little bit about the critical minerals and the situation that you spoke of, Mr. McGroarty. You said that the outlook is bleak when it comes to our mineral, critical minerals and particularly with our rare earths.

Mr. Zindler, you have stated that 2015 will likely be remembered as watershed for de-carbonization. I think Mr. McGroarty went on to state exactly how important these minerals are so that we can move forward with wind and solar and all of the smart technologies that we want, but we really do not want to be even more reliant than we already are.

I appreciate what you did in terms of outlining how, historically, we have been so reliant in certain areas. But instead of making progress it seems that we are actually going backward.

Now you have indicated that there are some areas that we might be able to reduce this dependence. The fact that we produce zero rare earths and are now, again, 100 percent dependent on China for our rare earths should be unsettling to all of us.

We have lousy permitting processes. Where, in terms of permitting for mines, minerals, if we are not the worst in the world, we are close to being the worst. I think Papua, New Guinea, is worse than us in terms of permitting. [Laughter.]

But you have also mentioned prospects for recycling and substitutes. You have indicated that really even with that, unless we do something to increase our production, we are not going to get ourselves out of this hole.

Can you speak a little bit to what you think our genuine alternatives may be when it comes to this reliance on our minerals?

Mr. MCGROARTY. Thank you, Senator.

Yes, there's—it's a very deep dependency, first of all. And in terms of bridging topics from oil and gas to hard rock minerals, as we look at, just from the energy side, new sources, new energy sources, alternative energy sources, I certainly would not want us to move from a dependency that has been difficult for us over 50, 60 years into a different sort of dependency for a whole series of new technologies.

The CHAIRMAN. In fairness, aren't we there already?

Mr. MCGROARTY. We are there.

The CHAIRMAN. Yes.

Mr. MCGROARTY. And that's why, as I said in my remarks, you know, all of the above. I mean we have to recycle. Such is our degree of dependency, we have to recycle. We have to reclaim the metals and minerals that are in, you know, the devices that we use every day, small and large, urban mining as they say.

We have to look, I didn't mention one in the oral testimony, but a lot of waste piles from mines that are no longer in operation that date back 50 years, 70 years, 100 years and the rate of extraction there is very dependent on the technology of the time and also, our interest in the metals and minerals of the time. So in many places around the United States we may have, we do have, opportunities to reclaim waste tailings by extracting the metals and minerals that are still there that either we did not do efficiently enough the

first go round or we didn't learn after them at all the first go round. And now they're part of that periodic table that we're suddenly interested in.

We should be doing all of that. We should be looking to substitute. But I am concerned about the easy discussions of substitution when you look, specifically, at what the possibilities are, the material scientists on these issues, where you're substituting for, you know, rhenium where we're 83 percent dependent and you can substitute for this particular applications of vanadium. But we're 95 percent dependent on vanadium, you know, vanadium from Kazakhstan and vanadium from China.

Are we looking at the degree of dependence that we're reinforcing or are we looking at the geopolitics of it? And so it pushes me back in the direction, we absolutely have to expand where we can, bringing new production into play.

The metals and minerals we're talking about, all of the devices that we use, we're at the very bottom edge of that. I really do believe there's a revolution going on in material science, and it is impossible that it's not going to put a lot more demand pressure on us. So that we're going to have to get very inventive too.

We're a very blessed nation. We're resource rich, but are we bringing these new resources into development or are we creating obstacles there?

I just think as this whole sphere is evolving so rapidly I don't think our ability to, kind of, process what the physicality of the needs. You know, we're bringing power from the wind and the sun. The physicality of bringing it into the grid, distributing it, as we talked about today. Those take devices. What are those devices made of? Are we going to be buyers of those devices or would you rather be producers of those devices?

So it's big issues for manufacturing, national security. And there's just a whole lot of metals and minerals where we're going to have to get used to treating in the same way as we've talked about oil and gas.

The CHAIRMAN. Well, the good news for us is that not only are we blessed with amazing resources when it comes to our energy potential, but we have some amazing mineral resources as well.

Senator Cantwell?

Senator CANTWELL. Thank you, Madam Chair.

I want to go back to electricity for a few minutes.

Obviously the business models are changing for utilities. I do not know if they feel that intensely at this moment, but I think future change will continue to drive that.

It used to be that vertically integrated monopolies built power plants, strung transmission lines, distributed, you know, the customer billing and now customers or consumers and businesses are demanding more control and getting it. They are looking at cleaner sources. Clearly there is a lot of change to what has been the traditional utility model.

We obviously want to continue to stir investment as well. I wanted to ask you, Mr. Zindler and Mr. Lucier, how do you see these business models evolving for utilities over the next several years, and how do we make sure that consumers feel even more empow-

ered to get the kind of efficiency that they want out of their energy prices?

Mr. LUCIER. Well, the utility business model—thank you, Senator Cantwell, for that very important question.

The utility business model has really been evolving rapidly, ever since Thomas Edison's Pearl Street Station in 1882. And the initial concept that served us well into the 1970's was the idea of economies of scale, to get low consumer prices we needed bigger and bigger operations. That broke down for a lot of reasons in the 1970's. It is actually the 70's, 80's and the 90's when we heard about distributed generation on a big scale.

Back then the focus was on distributed generation in terms of natural gas. But it still raised the issue of unbundling. I think that the model of cost-based regulation has been very helpful for providing infrastructure, but we're moving into a model now where scarcity-based pricing is what applies to the wholesale power markets.

And that's really the fundamental issue here. You need to define scarcity based pricing in such a way that you adequately price reliability. You adequately price load following. You adequately price ancillary services to keep the grid going.

And for that reason, I think, that you need to pay attention to a balance of industries and a balance of business models so that you have, not only the fly wheel, the power reserves that keep the grid going, but also the financial wherewithal to keep the entire thing flowing financially too.

Senator CANTWELL. Before Mr. Zindler answers I should just note we are pretty big fans of cost-based power in the Pacific Northwest.

Mr. ZINDLER. So I would just say that I think this is a very interesting time for utilities. And in particular the question you asked earlier around distributed generation is what is causing probably the biggest sense of disruption and frankly, concern.

Obviously when you, when a customer in your operating area starts generating power off their roof they don't need to buy as much, necessarily, from you as the utility. If you compound that by the fact that there may be so-called net metering where by effectively they can, you know, de facto sell the power back into the grid at a retail price, that also can be threatening. And so we have seen what I would say are at times confrontational situations between utilities and what have sprung up to be, you know, a relatively small industry growing of installers who have put these systems on peoples' roofs.

And I guess the one, hopefully, constructive statement I can make about that is that I would hope that utilities would view this trend as something that they want to participate in and take advantage of and find business models whereby they can be the ones who can help either be directly involved in doing the installing or partnering with some of these players. And I say that only because, at least in our view, this is, to a large degree, inevitable.

The costs are coming down. The technology is getting easier to put on peoples' roofs. It's going to happen. And so, it is probably better to be involved rather than being in conflict, necessarily, with what is an emerging industry.

Senator CANTWELL. Do you have a way to communicate that?

Mr. ZINDLER. Testifying before the U.S. Senate Energy Committee. [Laughter.]

Senator CANTWELL. I hope you are right. I hope you are right because I see, as I mentioned in my opening statement, everybody from Tea Partiers to environmentalists coming to terms on the fact that they do not want to be overcharged just to get more energy efficiency as they participate in creating energy. I think utilities have to understand that.

Mr. ZINDLER. And I, Madam Chair, will submit for the record Department of Labor statistics on green energy jobs verses fossil fuel jobs just to show the growth and amazing surpassing of that sector.

Senator CANTWELL. Yes?

Mr. LUCIER. Well Senator, I just wanted to follow up on the question of regulated utilities in the business model.

I think that with regard to distributed generation one of the key issues is really just cost allocation. How do you price the power? How do you price the grid?

And there's a lot of experimentation going on at the state level. And I think it's only a matter of trial and error, somewhat evolution until we find the answer that's going to work consistently across the country.

If you look at what happened last year in the equity markets the S and P were down about one percent, utilities were down about seven percent. But on the whole, I think, utilities have a much more stable business market. And utilities in the regulated space actually have their own interests in utility scale solar as well.

Where I'd really direct your interest would be the merchant power markets where last year we saw the stock prices of major merchants going down anywhere from 30, 40, even 70 percent. A lot of it having to do with natural gas but also a lot of it having to do with market price issues and policy questions about how markets would be structured in the future. So while I think that we can certainly accommodate the dynamic or distributed generation in a variety of ways, the area that's probably most urgent right now is the wholesale power market that serves two-thirds of the American public.

Senator CANTWELL. Yes.

I would just note on that, that we in the Northwest, I think, have one of the largest deployments of electric vehicles just because, again, we have cheap electricity. So there is an upside as well to the utilities. Clearly, I think as Mr. Zindler said, get on the side of the consumer and see the many applications here that could grow the business, but grow it in a different way.

Thank you.

The CHAIRMAN. Senator Cassidy?

Senator CASSIDY. Yes, thank you.

Mr. Sieminski, going back to where we left off our last conversation, whether or not the residential efficiencies can totally make up for this loss of projected power. You can explain it, if you will?

I am looking at EIA's Annual Energy Outlook figures and because others cannot look, I will mention them. Your 2015 base case had 4,070 terawatts in 2013 increasing to 4,691 terawatts in 2030.

A terawatt being 100 billion kilowatts, I think, a 100 billion kilowatts.

Now under the Clean Power Plan rule there is actually a savings, if you will, of 581 billion kilowatts which is to say, 581 terawatts. Can we really save 581 terawatts on residential efficiencies? I mean, is that part of your projections?

Mr. SIEMINSKI. Well, there are three big factors that are driving the deployment of renewables: tax issues, regulatory issues and technology issues.

Senator CASSIDY. Now going back to this question.

Mr. SIEMINSKI. Right.

Senator CASSIDY. Is the EIA really, now granted these clean power plant projections, but EIA is estimating a 581 terawatt increase over the Clean Power Plan rule in 2030. You had mentioned some of those savings will come from residential efficiencies. Is it reasonable to assume that we can save 581 terawatts from residential efficiencies?

Mr. SIEMINSKI. I'll have to get back to you with numbers. We have not done our final analysis of the Clean Power Plan overall impact. We will have that as part of the 2016 Annual Energy Outlook.

Where the savings come from that would be required with the reduction in coal are—there was also the other side of that which is the possible increases in output of electricity from natural gas and of course, renewables.

Senator CASSIDY. Now under the Clean Power Plan will natural gas stay basically stable?

It is amazing we have been looking at how much we would have to invest in renewables in order to make up for the shortfall. It is incredible, like the entire state of Massachusetts would be covered with the highest efficiency windmills sort of thing. It just does not seem practical. But that said, that is what the numbers show.

Okay Mr. Zindler, by the way, I apologize. You were right when I read your statement again, you do read renewables, natural gas accounts, for most of the increase. I thought you were including the two, but as it turns out, of course, natural gas is the lion's share of that. I just misread, so I apologize.

Mr. Lucier and then Mr. Zindler, distributed energy we speak of in terms of solar panels, but I remember being in California and people were putting in distributed energy natural gas generators at their office buildings. It comes to mind, Mr. Zindler, you said that an almost prerequisite for renewables to be competitive is for a high cost of electricity in that setting.

To what degree are the distributed energy sectors, actually natural gas in these areas of high electricity like California, as opposed to solar or wind?

Mr. ZINDLER. I can come back to you. I'll have to get back to you about exact numbers but the, at least in the most recent years, most of distributed phenomenon has been around solar.

Senator CASSIDY. Now is that in terms of volume of kilowatts produced or just in terms of installations?

Mr. ZINDLER. I believe in terms, well certainly in terms of installations because obviously these PV systems can be very small. In

terms of actual kilowatt hours produced it's probably a smaller margin. But still mostly, it's my understanding, it's PV.

But you raise a good point which is there's an interesting opportunity there, certainly, for gas. And gas is finding its way into the economy in lots of different ways. There was, in fact, there was a good deal of talk around natural gas vehicles. That was before the oil price collapsed. And now it's going to be more challenging, of course, for gas to compete in vehicles. But there are more and more ways.

I would say this that obviously when you do onsite natural gas generation you have to get the gas there and there's, you know, there can be those issues. But it's certainly not—there's nothing about the solar distributed, you know, generations or revolution that we're seeing that precludes gas also being a distributed source.

Senator CASSIDY. Gotcha.

Mr. Halff, you have done a really good job, excuse me, I am almost out of time, Mr. Lucier, I am sorry.

Mr. Halff, you did a really good job of showing the international instability that is being created in some countries have an increase in instability because of high energy, two things, either high energy cost and/or low energy, low income from energy production, if you will.

Now I am struck. Mr. Zindler says that for renewables to work the base load has to be expensive. Coal is cheap worldwide. India and China have clearly invested tremendously in coal in an effort to increase their economic growth. Obviously coal is cheap. It is there. They do not have to import it, that sort of thing.

If we are to bring in those sorts of high energy costs that seems to be a prerequisite for mass scale electrification of, let's say, India. That almost seems unaffordable for India.

I say that because economic growth is clearly in the interest of India. They are going to the Chinese to head off instability with economic growth. So in this context is it practical, is it foreseeable that those two countries, for example, will forego the use of their own natural resource, coal, for a renewable sort of grid?

Mr. HALFF. You are absolutely right that coal is very attractive for those countries and it's been the backbone of the Chinese energy sector. But we've seen some retrenchment in China, in coal use. Coal use has actually been declining lately.

And—

Senator CASSIDY. Now is that related to the economy declining or is that related to—

Mr. HALFF. Well I would say it's related to the economy in part because there's less industrial activity but also to the external costs associated with coal. And for instance, pollution in major cities has become a top concern with Chinese policymakers. It's deterred, for instance,—workers from going to the Beijing area. It's caused social instability. It's been a cause of poor taste and riots and—

So it's a top concern. And we've seen renewables take market share from coal in China, the margin. So it's not entirely just based on the domestic availability and the cost base. There's other factors at play.

Also some of the coal pipelines, for instance, or coal-run factories in China have been very ineffective. And those are the ones that have been targeted for closure first by the government.

In India, coal remains a very big part of the picture for the foreseeable future. But there the case for renewables comes from the idea of generated, of distributed generation and leap frogging some of the costs that have been associated with transmission and distribution in other emerging economies after they've gone through periods of expansion.

Senator CASSIDY. Gotcha.

Mr. Zindler, I am sorry, I am out of time. But is that okay? Mr. Zindler?

Mr. ZINDLER. I would just jump in and say I think on India in particular I'm happy to share with you, Senator, some of the really exciting things that have gone on around renewables and particularly distributed solar, as Antoine mentioned.

There are 400 million people in India with no access, basic access, to electricity. And one of the most interesting developments we've really seen in just the last few years as a result of the lower cost of solar are very tiny microsystems that are being distributed for \$100 or less into rural communities that provide just basic power needs to turn on a light, you know, a radio. These are the most basic needs that people have that are starting to be served.

And frankly, if you do the math on that versus building a giant coal plant with the hub and spoke network, solar definitely competes.

Senator CASSIDY. Totally works on that. It is just the energy intensive enterprise that actually elevates them out of poverty, and that is, I guess, the more demand. Step one for 400 million people that was just to turn on a light bulb.

I yield back. Thank you.

The CHAIRMAN. Thank you.

I have got just a couple, hopefully brief, questions here. I want to go back just for a moment on natural gas and the reality that we have got to be able to move that natural gas and some of the opposition to infrastructure development.

You noted this in your testimony, Mr. Lucier, and I think you state opposition to infrastructure development that could prolong the supply glut and put the timing of relief in question.

So the question to you is if we have a situation where pipeline siting and permitting is delayed on a bigger scale what happens? What do you think the consequences are for natural gas? Could these types of impediments and we are seeing them, believe me, we are seeing them, particularly in certain parts of the country where there is a nimby attitude that while we want to have pipeline transmission but we do not want it running through our state, move it through somebody else's. Could we be in a situation where because of just that, kind of, political opposition we have a real threat to natural gas supply itself?

Mr. LUCIER. Well Senator Murkowski, we have too much of a good thing in some parts of the country. In the Marcellus, obviously, there's a tremendous amount of gas. And it is really building up there. We don't have the take away capacity.

The CHAIRMAN. Right.

Mr. LUCIER. What that means is that the price of gas is lower in that Marcellus region which corresponds to PJM even MISO. And this is putting huge pressure, not just on power prices but coal-fired power plants and in particular on nuclear. So take away capacity for that gas is key.

On the other hand, just three, four, five hundred miles, depending on where you count, we have New England. New England which is just totally dependent on gas for its merchant power. Very efficient network, but they don't have access to this great gas supply from the Marcellus.

We've been fortunate this year to have warm weather. We've had El Nino shining on us. But we came very close to severe weather events during the Polar Vortex in 2014, not once but twice. And New England is still in a situation where they can still be one weather emergency away from a serious power or heating crisis. That shows the urgency of delivering gas from areas that are gas rich, in fact, oversupplied, to areas that are actually quite exposed right now.

So I think in your oversight you should definitely pay attention to the efforts to build pipeline capacity into New England.

But on the broader question of delivering natural gas to provide clean gas generation we're seeing a record number of pipeline proposals at FERC right now that is straining the resources at FERC. They're actually doing quite a good job to move forward.

But we're also seeing FERC literally surrounded by hunger strikers who are demanding that FERC issue their new permits for anything. And the litigation is also slowing down those pipelines. And while natural gas is still a carbon based fuel it's cleaner than the alternatives.

I was driving through the coal country of Southwest Virginia this time last year and noticed anti-pipeline signs. The State of Virginia wants to build natural gas power plants to reduce its overall dependence on coal, but if you can't build a power line in Virginia if the Atlantic coast pipeline is held up.

People in my client meetings are constantly asking about what's happening with the Constitution pipeline, what's happening with any number of other projects. There is a lot of uncertainty among investors as to whether you can actually build a new power plant if you can't actually supply the gas to them.

The CHAIRMAN. This is a huge issue for us, and they do not get near the attention. This is why I think it is going to be important that we are able to move some of our energy policies forward such as we have within the Energy Policy Modernization Act that we hope we will bring to the floor here very shortly.

In this same context then about the impact of natural gas and what it does to other energy sources, whether it is coal or whether it is nuclear, I want to ask Mr. Sieminski about your projections on nuclear because in your chart, your table, number one on non-hydro renewables expected to make up nine percent of electricity generation by 2017. You indicate that by 2017 actually our nuclear generation makes up less of that overall portfolio than it has in years past.

If we have a situation as Mr. Lucier and I have just been talking about where you are not able to either move that gas to where it

needs to get what does this do to your projections? How do you see the viability of nuclear as part of the energy portfolio going forward given what we are seeing with some of the constrictions on natural gas?

Mr. SIEMINSKI. Senator, I think in our annual energy outlook we have just a small amount, you know, 0.8 I think or it's 800, the difference between 789 and 808 billion kilowatt hours of generation from nuclear in the annual energy outlook. In the clean power plan, the proposal will have the final numbers out soon, but that didn't change very much. I would say that was nuclear is flat because we have total electricity consumption growing by about 0.7 or 0.8 percent per year. Nuclear's share is slightly decreasing.

Back to the question that Senator Cassidy was asking. We do see under the clean power plan and the extension of the PTC and ITC for wind and solar, the tax credits as well as improvements in technology that have been talked about by other members of the panel that there will be improvements in the use of solar and wind as you look out. But we're also assuming that natural gas-fired generation goes up both in the annual energy outlook and in the clean power plan.

The amount of generation under the clean power plan will come down a little bit. It will be replaced by more wind and solar and natural gas, not so much nuclear, back to your question, lower coal. But the total amount of generation is just a little lower.

And so you don't have to have massive changes in the efficiency in the residential sector to make up for that. So basically residential users will be using more solar and wind capacity as well as natural gas capacity, but not nuclear.

The CHAIRMAN. Not nuclear.

Mr. Zindler, I am out of time, but if you wanted to add something very quickly, certainly we will give you that opportunity.

Mr. ZINDLER. Yes, just very quickly back on the gas pipeline question.

I did want to just note that, you know, we're looking at our forecasting where 2017 will probably see more capacity added for natural gas delivery than we've seen since 2008 with about 65 billion cubic feet per day being added over the next three years. There's a lot of pipelines that have been approved that are coming online that are directly related to that Marcellus and the Utica, and it's worth noting that I think that that may ease some of the bottlenecks that have existed so far.

The CHAIRMAN. We are hoping so. Thank you.

Senator Hoeven?

Senator HOEVEN. Thank you, Madam Chairman.

I want to go back to Mr. Sieminski and Mr. Halff in terms of their energy, oil and gas price outlook.

Mr. Halff, you talked about this black swan concept whereby OPEC and others may pump a lot of their oil now with the thought that later there may be less demand.

Given the Saudi needs about \$100 a barrel. In fact, Russia needs about \$100 a barrel to cover their all in costs for, in terms of their spending in the budget. How does that impact they're continuing to produce at a high rate with prices as low as they are and how long do they continue that?

Mr. Halff?

Mr. HALFF. Thank you.

So Saudi Arabia can produce and endure on these reserves for some time. There's no immediate pressure there. Certainly they have been dipping in their reserves.

Senator HOEVEN. Are you talking about their financial reserves?

Mr. HALFF. Yes, yes. But they have the capacity, perhaps more than any other producers, to continue blending at fairly low prices for quite a while. However, we're seeing signs of pressure and we're seeing signals that they may be considering some quite revolutionary changes in the economy. There's talk of privatizing the national company to some degree. It's hard to say how much of that is for real, but there's signs of pressure and signs of a shift in the makeup in the economy and the mindset.

Russia, it's a different situation because Russia has, in a way, benefited from the collapse of its currency. So its production costs have come off dramatically compared to the revenue which continues to be in dollars. So that, I think, partly explains why Russia has done so much better than anybody expected.

In fact, its production has increased dramatically since things started looking really bad for Russia, since the beginning of the price drop and the imposition of international sanctions. Production had been expected by many to fall. And it's actually increased steadily. And Russia has been producing at record levels.

So how long can this go on? Not forever. One advantage that the Russian companies have had also is that they haven't been affected by the price drop as much as the state revenues have. Their tax system is such that the companies have managed to keep, to hold onto, a lot of the take and the state budget has suffered most from the price drop.

Now the companies go to state finances for funding. So that will, that's where, I think, the companies will hurt eventually. And that's what going to put a stop on the kind of steady production that was a growth that we've seen over the last few months.

Senator HOEVEN. Aren't those factors though going to drive prices higher at some point because how long, I mean, if their all in cost is \$100 and they're selling at \$30 or \$40, how long can they sustain that?

Mr. HALFF. There's no question in my mind that the price will rebound and will rebound even steeply. When that will happen it's very difficult to time. Is it going to start at the end of 2016 or sometime in 2017?

Currently the futures markets are pricing oil in 2020 under \$50 a barrel. I don't think that's realistic. And you know, futures market are not particularly good forecasters of long term prices. Their track record is quite poor. In my view it's almost a given that prices would be significantly above \$50 by 2020. Now the timing is difficult to assess.

And the capacity to grow production from many countries would be degraded. Russia, I don't think, will be able to continue producing at the kind of growth base that we've seen.

Iraq has dramatically increased production, but it will be hurt by its incapacity to pay the companies operating there. So the dramatic increase we've seen more than one million barrels per day of

capacity since the price collapse and the takeover of Mosul by ISIS. That's not likely to be sustainable to continue.

And we're seeing now production drops in the U.S. in light, tight oil production. Those declines, I think, will continue. Eventually there will be a rebound. Light, tight oil is presumably much more price responsive, will be able to come back quickly when the price turns.

Senator HOEVEN. What is that?

Mr. HALFF. Shale oil.

Senator HOEVEN. Oh, yes.

Mr. HALFF. For short.

Now one of the big questions is will shale oil when it comes back to the market, when both comes oils come back, will it come back at the kind of pace we've seen over the last few years or at the diminished pace?

One key factor there would be the degree to which the cost deflation that companies have enjoyed since the price collapse whether that will stay or how much will re-inflation we're likely to see as demand for oil services rebounds with the price increase.

Senator HOEVEN. Mr. Sieminski, your thoughts?

Mr. SIEMINSKI. With the Chairman's permission.

Senator HOEVEN. Well, would you like to—

The CHAIRMAN. Why don't you continue?

Senator HOEVEN. Thank you.

Mr. SIEMINSKI. Senator, I grew up in Pennsylvania and not in the great state of North Dakota but there is a phrase that might apply here. This ain't my first rodeo. I've seen seven big price declines, and I've seen six big price increases. I think Antoine and I agree that prices are coming back.

I think getting at the heart of your question, let me just try to separate it into two parts.

A number of countries, Iraq was in there. Venezuela was also in there, had numbers calculated, you know, a while ago, and they needed \$100 to make their budgets. And in Russia's case the collapse in the ruble and the strength in the dollar have really improved their position.

So they export oil. They get dollars for it. Their costs are in rubles. So that currency exchange ratio has really helped Russia.

In the Saudi case they might not need \$100 a barrel anymore either because they've undertaken price reform. They're now starting to look at ways to charge people a little bit more for gasoline and electricity and so on. So, you know, they can make some changes.

But I think coming back to the heart of your question is can we have \$30 a barrel oil continuing indefinitely into the future? And I think the answer to that is no. Prices could go lower. We could see \$20. Why? Because the cash costs, there are three layers of costs in the oil business. There are cash costs and that's what you need to cover your immediate bills in a sense. And that's down near \$20 a barrel.

And then you've got mid-cycle costs. This is kind of like what you need to kind of hang on, it's like you might not be doing really well but you're paying some of your debts and so on. So you're not being shut down. That's probably in the range of \$40 to \$60 a barrel.

And then there are the full-cycle costs. What does it actually take to go out and find more oil and to meet rising demand for oil because every forecast that I've seen assumes that. And those numbers are at least \$50, I think, and possibly as high as \$75, maybe even \$80 a barrel.

So at some point I think we've got to get back to that full cycle cost range because if we don't this big buildup that we've seen in inventories over the last year and a half is going to get drained down. And then something will happen and we could come back to the Senator's question. I think it was your first question, Senator Murkowski.

What about Venezuela? They're exporting two million barrels a day on net. And that could go off the market given the social, political turmoil in that country. And then we wouldn't be talking about these layers of costs we'd be talking about, you know, what does it take to replace two million barrels on a global market where there's not a lot of spare capacity.

Senator HOEVEN. I am going to— [Laughter.]

I have a couple more questions but I would certainly defer if you have, if you want another round.

The CHAIRMAN. No, I'm just sitting here enjoying this exchange.

The Alaska legislature is convening this morning for their inaugural, the kickoff of their session, and the questions that are being raised in the discussion here is as important as anything for a state like mine that relies so heavily on oil and a state like yours that has relied so heavily. We have seen what happens when the price tanks and what that does to your economies.

So please, continue, and I will have some when you are done.

Senator HOEVEN. Great. Thank you, Madam Chairman.

The testimony really is important. If you look over the last several years the testimony that you and others provided, the information you provided was very important.

We just recently, led by our Chairman, lifted the oil export ban which had been in place for 40 years. That was only possible because of the information you put forward that actually showed the benefits of doing so in terms of jobs, economic growth, energy security, lower prices at the pump and all those things. So in terms of creating the public policy we need this testimony, I think, matters dramatically so that we do create an environment wherein American entrepreneurs and our companies can unleash their ingenuity and compete.

Mr. Halff, your comment about reducing the price curve and the ability to respond to the markets I think is an incredibly important key just like understanding long term, the pressures that will drive underlying pricing.

It is not just important to fossil fuels. I think it has a dramatic impact on what happens and a realistic approach in terms of renewables and other types of energy.

I want to shift, Mr. Lucier, you went to coal for a minute. What is the impact going to be from the Administration's three-year moratorium on leasing coal on Federal lands? What are the ramifications going to be for the coal industry as a result? This is now in addition to the CO2 regulations the Administration has put for-

ward, stream buffer rule regulation, many other things. Now what is the impact of this three-year moratorium going to be?

Mr. LUCIER. Well Senator, thank you for that question. That's actually an extremely important question. I haven't prepared an analysis of the impact of the three-year moratorium on coal leasing, but obviously it's going to be quite significant because it points to assets which are being tied up through extended studies and which may actually be developed in the future, only subsequent to, you know, increased charges, carbon charges, land access charges, increased royalties, etcetera.

So this is interesting. The coal industry right now, as you know, is tremendously depressed. We actually have over supply in coal which is driving coal prices down.

But I think you need to watch what the Administration is doing here to see what this means for all fossil sources because if we have to have programmatic environmental impact statements, looking at leasing on Federal lands for coal. This is clearly the first step for doing such programmatic environmental impact statements pertaining to leasing oil and gas on public lands too.

So I think the economic significance given coal's depressed state is actually not a major issue right now. But the precedent this sets for all other fossil fuels and for public lands generally, is quite substantial.

Senator HOEVEN. Thank you.

Mr. Sieminski?

Mr. SIEMINSKI. Senator, just some facts on this.

In 2014, and that's the latest data, 42 percent of coal produced, U.S. coal production, was from Federal lands. That's a fairly high number. And the main states, Montana, Colorado, Wyoming, New Mexico, Arizona, and North Dakota, Senator, I think, possibly Alaska might even have some coal production from Federal leases. So there are issues there that in the longer term could be impacted. In the short-term there's probably enough property under lease to maintain output.

I wonder if I could take a minute to come back to your question about—I'm going to risk talking a little bit about policy which I am not supposed to do. I want to do over on your question, Senator.

The CHAIRMAN. I knew if we kept you for longer we could get some policy. [Laughter.]

Mr. SIEMINSKI. I think if you were looking to say what could you do to enhance U.S. energy production in the oil area, maybe even in a few of the other areas that the issues of infrastructure are really important and policy is the deal with the interest. I was reminded, Senator, because you were asking about the ability to move natural gas around. I think the ability to move oil around is an important one. Even crude oil products, the colonial pipeline which runs up into this area is running pretty full.

Even issues like the electric grid which is being looked at by many people, including the Department of Energy.

The Strategic Petroleum Reserve and the ability to get oil water borne from the Strategic Petroleum Reserve so that it can be moved to other parts of the United States and the DOE is looking at that. In fact, I think it was part of the law that just passed that instructed DOE to do so.

So there are a lot of policy issues associated with improving the midstream, so not so much the well head. But I think that bit in the middle before we get the products to consumers that are, I think, we're really ripe for a good look at the policy issues surrounding that.

Senator HOEVEN. Thank you, Mr. Sieminski. I think that is absolutely right on, and I appreciate it.

Mr. Lucier, I think you bring up a very important point when you describe how the moratorium that the Administration has put forward is right now on coal. But what are the ramifications of that for other types of energy like oil and gas? I think your point is very well made and it's deeply concerning.

I will just wrap up with this question and that is as part of the legislation that our Chairman and Ranking Member are advancing one of the provisions included in the LNG Permitting Certainty and Transparency Act which Senator Barrasso is the lead on and I am co-sponsoring on with our Chairman and others. I would like some sense from, and I would start with again, Mr. Sieminski, Mr. Halff, but from any of you, in terms of what do you see, if we are able to advance that legislation and more readily allow for LNG export, what do you see the ramifications in terms of actually making a difference with some of our allies? For example, with creating markets here at home but actually making a difference for some of our allies in Europe and so forth in terms of reducing Russia's tremendous control because they are the energy supplier to Europe. Are there other things that would help?

Mr. SIEMINSKI. Right now I think that the main impediment to LNG exports is not the permitting which is, I mean, there are a number of Federal agencies that are involved in permitting. The two main ones are the Federal Energy Regulatory Commission for the engineering and environmental aspects and the Department of Energy Office of Fossil Energy for the national interest.

Senator HOEVEN. You are not just saying that because you are part of the Department of Energy? [Laughter.]

Mr. SIEMINSKI. I think that there was at one point, there was a view, Senator, that there was a bottleneck there. But that doesn't really seem to be the case. The—there has been an alignment between the Department of Energy and the Federal Energy Regulatory Commission on the permitting.

So I think that coming back to what are the issues. I think that it's largely the economics. With lower oil prices the spread between global oil prices and lower U.S. natural gas prices has narrowed, and it's made it more difficult to export LNG or to look at the economics of LNG exports. If we should see a recovery in oil prices that would probably do much more to improve the prospects for further LNG exports.

In EIA's numbers we do have LNG exports going up. I mean, it still makes sense into the Asian markets and possibly into Europe. So I think that things will look very different at the point that we get back more toward those full cycle costs associated with oil prices that you were asking about earlier.

Senator HOEVEN. Mr. Halff?

Mr. HALFF. Well I think the rise in the future price in U.S. LNG exports that's part of a game changer, the real transformation of

the gas market. And I would just point out a couple of ways in which things would be different.

One is the growth of gas as an international, global market with probably different pricing mechanisms looking forward and more international competition. That's going to be very important for European energy security because it would provide an additional source of gas supply in addition to the sources that Europe relies on right now.

But also very important for Asia. And I think one key factor would be, one key way in which energy would have an impact, and it's not just U.S. LNG based or so. It's Australian LNG and Qatari LNG which are increasing. It would be to allow for more international competition between oil and gas and an increased use of gas as a bridge fuel in the energy transition.

Senator HOEVEN. Mr. Lucier?

Mr. LUCIER. Well Senator, you're really correct that if we want to help our friends, especially our gas consuming friends in Japan, in Asia and elsewhere, we do want to increase global supply. This will certainly help Europeans looking for broader supply.

But it's not just our friends that we have to think about. We have competitors too. And in a very tight global LNG market right now there could be competition to see who actually builds the export facilities and to see who actually get the export business.

So anything we can do on the margin that means that U.S. projects have an edge or U.S. projects have more certainty against last minute delays does help U.S. producers and it does improve our competitive position. Sure, it helps our friends, but I think we need to think of ourselves in comparison to competitors as well.

Senator HOEVEN. Mr. Zindler?

Mr. ZINDLER. Just a very, very quick point which is that I think the LNG play, I agree with what everyone said on LNG.

One area I would say take a look at which has been interested is exports into Mexico which is not LNG but just simple cross border stuff. And that, we think, is going to continue to rise. It's a very interesting area for the gas market. And there's major energy reform underway in Mexico as well that could drive even further gas demand as well.

The CHAIRMAN. All excellent points.

Thank you.

Senator HOEVEN. Thank you, Madam Chairman.

The CHAIRMAN. Thank you.

Senator Cantwell?

Senator CANTWELL. Senator Hoeven, that was the longest question session I think I have seen in this Committee.

The CHAIRMAN. But it was good—

Senator CANTWELL. Well, yes, I know, I understand. I think it's been a good discussion and panel.

And again, I thank the witnesses.

Mr. Halff, to me I do not necessarily want to argue as much about the past as I want to plan for the future. I think your answers to my colleague, Senator Cassidy, about the Chinese are to point that part of the discussion here is also political and that consumers are demanding a different world and China is responding to that.

So no, I don't think India is going to build coal plants galore when they have issues, nor do I think that China is going to pursue that. I do think that the President's action since we already have 20 years of coal under lease, I think is very important that we assess for the taxpayer what the 30 years beyond that looks like and make sure the consumers are getting a fair price.

My question is to Mr. Zindler on the corporate installation of renewables because I think this is also where consumers are somewhat driving behavior, but also I think corporations are driving efficiency. I think corporations are looking at it as a win/win. I think Walmart looks at it and says energy efficiency is a win for us. It's a win with consumers, and it's a win for our power. I think that is where Google and other people are. What do you think the renewable purchase from corporates to do grid scale renewables is going to look like for 2016 and into the future?

Mr. ZINDLER. That's a good question.

So last year I think was roughly about a third or so of all power purchase agreements that were signed in the U.S. for large scale clean energy were signed by corporations, essentially directly to buy the electricity themselves.

And I think the motivation there is primarily economic which is that essentially it gives you the opportunity to know that what your price of power is going to be over a long, fixed period of time and essentially lock it in. It's not that they're buying all of their power from renewables, but if they can essentially lock in some chunk of it then they can offset the risk of fluctuations in electricity prices going forward.

So that's been one of the main motivators I think that we've seen take place so far. And you're right in noting Google, certainly Microsoft in your state, but not just, you know, tech companies, but others as well. Kaiser Permanente, IKEA, others have been involved in different ways in renewable energy.

So I think that that's how they view it is that you essentially eliminate one risk which is the unknown of electricity prices which are tied to a variety of factors we talked about here today including gas prices and other things and you essentially just lock it in. So that is an area we think will continue to look interesting.

I will say this which is that it is predicated on the notion that you have fears about power prices rising. And if power prices go down then corporates might get a little less interested in this area because then they're not as worried about the fluctuation in prices because they feel like they could go down in the future.

But thus far, most of the attempt has just been to lock in a price that you know it's going to be over a long, fixed period of time.

Senator CANTWELL. I think what is happening is consumers find out more information about pollution and particularly in China they are raising great concern.

Mr. ZINDLER. Yes.

Senator CANTWELL. I think people are trying to respond. But I see it across the board even in marketing that i3 which is a great vehicle by BMW, who is advertising not only the fact that it is this next generation car, but that it is also built with renewable energy. Their plant run in Moses Lake is using hydro power. They are trying to say it is the all renewable car from the beginning of its ori-

gins and how power was generated to create it and the fact that it is recyclable material within the car.

I think people are trying to win in the marketplace on this issue, and I think the consumers are demanding it. So I think it is probably both, at least for now anyway.

I definitely think it is something for us to continue to look at how grid-scale renewables, solve some of the questions that we want answered as it relates to distributed generation. Moving forward I don't know if you have anything else on that point, Mr. Lucier, about questions that we want answered in the electricity grid. But obviously, you know, there is everybody from Elon Musk to many others who are putting lots of ergs into battery technology as it relates to giving us more flexibility on renewables and building that capacity into the grid.

Mr. LUCIER. Well that's a big—well thank you, Senator Cantwell. That's a big, open invitation. I'm not sure what I can say succinctly in 30 seconds.

I mean, clearly, putting power storage on the grid and combining it with distributed generation on the edge of the grid is something that really could revolutionize the industry. It certainly does provide a lot of solutions for many issues.

I just point out though that the grid is a totality and that while the grid has an edge, the grid also has a core. And at the moment it's the core, the core transmission that works the core generation assets that are keeping the grid alight, if you will.

I think back to discussions of things like participant funding or stranded assets back in the 80's and 90's. That was actually part of a discussion that led into distributed generation too in the 90's. So these are not necessarily new issues.

The key point is that power has a price. Access to the grid should have a price. Regulators who do cost allocation are very good at figuring this out. And over time in market evolution we do figure out ways in which you can fairly price resources whether it's the energy side or the infrastructure side.

So I'm actually very confident that we'll see a very robust partnership develop. I think there's an opportunity for many thousand flowers to bloom. And I think we'll see a lot of innovation going forward.

Senator CANTWELL. Well I certainly like that analogy. And I definitely think that what we get out of the grid is a layer of efficiency. When I look at that ability to have that technology, not only utilized in the United States, but around the globe, now that is a major transformation.

Thank you, Madam Chair, for this hearing.

The CHAIRMAN. Thank you, Senator Cantwell.

And thank you, to each of you gentlemen. I appreciate the time that you have given us. We have gone well over our usual time, but when you think about what has been discussed here today we really are at that point of substantial change.

Mr. Zindler, in your testimony you say, "A fundamental rethink is now well underway about how energy gets produced, delivered, consumed and managed in many parts of the world including the U.S."

I would think, based on the testimony from each of you that you would all concur with that. When you think about where we are, the discussion that was raised about coal. The impact that we will have of this three-year moratorium on leasing on Federal lands. The impact of the clean power plan.

When you think about where we are with natural gas, what's happened with the low prices, the potential for some disruption because of infrastructure issues.

When we talk about the necessity for critical minerals and how that will allow us to build out our renewable energy sources through enhanced technologies, and yet we recognize that we are going in the same direction with critical minerals that we were historically with oil.

The oil picture we could take a week of hearing in just understanding what is going on in Iran and Iraq and Saudi Arabia and Venezuela. We did not talk about Libya. Russia. Layer in now in the discussion about our ability to export onto the global oil market and what that means.

The impact to all of this on nuclear as we are seeing changes or our policy decisions made through clean power plan. What the price of natural gas does to nuclear, what we are seeing there. Distributed generation in the mix of renewables. The policy decision that we made last month to allow for a continuation of the production tax credits there. The policies that we are putting in place juxtaposed to the political and geopolitical aspects of energy. The pricing situation. Infrastructure.

It begs for a modernization of our energy policies, and that is what Senator Cantwell and the members of this Committee have produced in an 18 to 4 vote moved out of the Committee in July. It might not solve all the problems in the world. In fact, I think we can guarantee that it will not. But what it does do is updates our energy policies from eight years ago which desperately need updating in all of these different areas whether it is permitting, whether it is how we look at our grid. It is how we move forward in the energy space.

So my hope, and I think Senator Cantwell's, is that we will be able to move to this quickly. I think it is an imperative. An imperative for our economy because when we are talking about energy security, to me that translates to national security which also translates to economic security.

So we have a lot to offer in this space. Know that we will be working on it.

But we appreciate your guidance this morning. I do not know if you have made the crystal ball clearer or have just reminded us as to how cloudy and complex it really is, but we appreciate your wisdom.

With that, we stand adjourned.

[Whereupon, at 12:28 p.m. the hearing was adjourned.]

APPENDIX MATERIAL SUBMITTED



Department of Energy
Washington, DC 20585

August 17, 2016

The Honorable Lisa Murkowski
Chairman
Committee on Energy and Natural Resources
United States Senate
Washington, DC 20510

Dear Madam Chairman:

On January 19, 2016, Adam Sieminski, Administrator, U.S. Energy Information Administration, testified regarding the near-term outlook for energy and commodity markets.

Enclosed are answers to seven questions submitted by Senators Bill Cassidy, Steve Daines, Elizabeth Warren and Ranking Member Maria Cantwell to complete the hearing record.

If you need any additional information or further assistance, please contact me or Fahiye Yusuf, Office of Congressional and Intergovernmental Affairs at (202) 586-5450.

Sincerely,

A handwritten signature in dark ink, appearing to read "Christopher King", is written over a horizontal line.

Christopher King
Principal Deputy Assistant Secretary
Congressional and Intergovernmental Affairs

Enclosures

cc: The Honorable Maria Cantwell
Ranking Member



QUESTIONS FROM RANKING MEMBER MARIA CANTWELL

Q1. How do you expect lifting of the oil export ban will affect the transportation of crude oil throughout the country, particularly by rail?

A1. With the recent decline in lower-48 crude oil production and the addition of pipeline infrastructure, the latest available data (through November 2015) show that movements of crude by rail have been declining from the recent high level attained in May 2015. EIA is currently forecasting lower-48 production declines to continue well into 2017, which should continue to exert a downward influence on crude-by-rail shipments.

Future trends in crude-by-rail shipments will depend on both the level of production and the development of pipelines and other infrastructure to move crude. Under price conditions conducive to increases in domestic crude production increases, increases in exports enabled by the recent removal export restrictions would likely be made from the Gulf Coast, where oil would flow via pipeline. The removal of export restrictions tends to incentivize increases in Gulf-directed pipeline capacity, which tends to reduce crude-by-rail movements.

Turning to the West Coast, the recent policy change would be expected to lower crude by rail deliveries to the West Coast relative to a no-policy-change scenario in scenarios where domestic production reaches a level where crude oil exports would be expected to grow significantly. Current crude-by-rail shipments to the West Coast have largely been motivated by the opportunity to supply crude to U.S. refiners. Domestic crude being delivered via rail to Washington State is well suited to be run by West Coast refineries, which currently must import almost 50% of their supply.

Any crude exported from the West Coast would have to compete in Asian markets which are well supplied from the Middle East. Moreover, even if market conditions were somehow to allow for profitable exports from the West Coast, current marine facilities in Washington State are ill suited for crude exports due to both their capacity and the size of vessels that can be accommodated. The Magnuson Amendment effectively limits expansion or new construction of marine facilities.

Finally, differences between the ability of Gulf and West Coast refiners to absorb incremental domestic crude supplies also suggest that the lifting of restrictions on crude oil exports should not in itself increase rail shipments to the West Coast.

- Q2. In light of the electric utility consolidation trends in 2015, state and federal oversight is more important than ever to protect consumers. Is this consolidation trend expected to continue throughout 2016?
- A2. EIA identified two mergers and acquisitions among electric utilities in 2015: the acquisition of the Tampa Electric Company's holding corporation by Emera; and the pending merger of Pepco Holdings, Inc. with Exelon. This compares with two mergers in 2014, five in 2013, and four in 2012. This activity is allowed for by the Public Utility Holding Company Act of 2005 (PUHCA 2005), which significantly reduced the barriers to cross-state ownership of electric utilities created by PUHCA 1935. Mergers of electric utilities are approved by FERC and by the utility commissions of the affected states. EIA does not currently collect, track, or analyze the detailed corporate financial information that would allow us to assess future merger and acquisitions for this sector.

QUESTIONS FROM SENATOR BILL CASSIDY

- Q1. In the Clean Power Plan's Regulatory Impact Analysis, the EPA projects that when completely implemented, the CPP will result in electricity generation of 4110 terawatt hours, that is 8% below its own 2030 base case (4467 terawatt hours) and 14% below what EIA believes will occur based on current policies (4691 terawatt hours). You stated during the hearing that a lot of the improvements in energy efficiency (or reduced use) have come about in households, can we truly save this 581 terawatts with a majority of the savings coming from residential efficiencies or will they have to come from elsewhere?
- A1. EIA's analysis of the proposed Clean Power Plan (published in May 2015) finds that energy efficiency over and above what is expected without the Clean Power Plan contributes a significantly smaller amount to compliance than in EPA's analysis; EIA's analysis shows incremental efficiency savings over the no-CPP baseline of 81 terawatt hours in 2030. When it comes to making electricity usage more efficient, considered as part of the CPP, then residential buildings do register a large and sometimes predominant share. Using the results from EIA's analysis of the proposed CPP rule, of the four demand sectors, the residential building sector accounts for 37% of the savings in total electricity usage in 2030, which is the largest share of savings among the demand sectors (although not quite the majority). Most of the rest of the electric demand savings occur in commercial buildings, which share many end use characteristics with residential buildings. EIA has found much more limited potential for electric demand savings in the U.S. industrial sector, although research is ongoing in this area.
- EIA will analyze EPA's Final Clean Power Plan as part of the 2016 Annual Energy Outlook.
- Q2. Under the Clean Power Plan, it is projected that electricity generation by renewables (hydro, wind, solar, and other renewables) will account for 25% of total energy production. What would be the cost of investment required to deploy these technologies, potential cost to energy consumers and cost to taxpayers used to subsidize such deployment?
- A2. In EIA's May 2015 report, *Analysis of the Impacts of the Clean Power Plan*, which modeled based on the proposed Clean Power Plan rule as of August 2014, EIA projected that renewable generation would represent 25% of total electricity generation in 2030 in its Base Policy case. Relative to a case without the Clean Power Plan, the cumulative net present value of capital investment in new generating technologies between 2014 and 2030 was \$110 billion higher, representing the shift to the relatively higher cost renewable capacity that was built to comply with the rule. The analysis showed that retail electricity prices averaged 5% higher between 2020 and 2030 under the Base Policy case,

while both total electricity expenditures and average household electricity bills averaged 3% higher over the same period. Expenditure changes are smaller in percentage terms than price changes as the combination of energy-efficiency programs pursued for compliance purposes and higher electricity prices tends to reduce electricity consumption relative to baseline. EIA's analysis did not include the extension of tax credits for renewable technologies that were included in the Consolidated Appropriations Act, 2016, that was enacted in December 2015. Those tax credit extensions could result in some amount of transfer of the costs for new renewable capacity from consumer electricity bills to the Treasury, which could have implications for taxpayers. The final rule, promulgated last summer, has somewhat different provisions than the proposed rule analyzed by EIA; while results described above are reasonable indicators of direction and magnitude of impact, they may not match expected impacts of the final rule. EIA will analyze EPA's Final Clean Power Plan rule as part of the 2016 Annual Energy Outlook.

- Q3. Environmental groups such as the Sierra Club tout the ideal of a Coal Free United States. If we are to assume that all energy generated from coal will be replaced by renewables what would be the cost of investment required to deploy these technologies, potential cost to energy consumers and cost to taxpayers used to subsidize such deployment?
- A3. EIA has not analyzed a policy that would require the replacement of all coal generation with generation from renewable resources. Previous analyses by EIA of policies such as the proposed Clean Power Plan, renewable portfolio standards, renewable tax credits, and other types of carbon regulation, indicate that results such as the cost to energy producers, energy consumers, and taxpayers would depend on the particular policy mechanisms employed. Policy choices such as the use of tax credits, the use of emissions trading, and the initial allocation of emission trading allowances where used, may affect the overall cost of compliance, and largely determine how such costs are allocated among stakeholder groups (producers, consumers, and taxpayers). Even when the total impact on generation mix is substantially similar, policies of differing design may have substantially different costs and cost allocations.

QUESTION FROM SENATOR STEVE DAINES

Q1. I understand that estimates for national oil company production range between 60 and 75 percent of world production and national oil companies hold between 80 and 90 percent of world reserves. Do we know what the typical fixed and variable cost mix is for national oil companies? Do you believe national oil companies have an incentive to produce oil regardless of the international benchmark price as long as their variable costs are covered?

A1. For most oil companies, the costs of finding oil reserves and drilling wells are typically greater than the costs of producing or lifting oil out of the ground once the well is drilled. Once a well is producing, a company will likely continue to operate the well as long as the sale price exceeds the lifting costs. However, if oil prices are low, companies will cut investment spending to find and develop oil reserves, beginning with property acquisition and exploration budgets, and then cut development spending for existing fields.

Very little financial information for national oil companies is publicly available. It is generally accepted, however, that the costs of finding and producing oil for OPEC national oil companies are among the lowest in the world. OPEC countries likely have the financial incentive to continue current production at current price levels, but may reduce investment in future production.

A bigger consideration for OPEC countries is the oil revenue contribution to the governments' budgets. The governments of Saudi Arabia, Russia, Iraq, Venezuela, Nigeria, Angola, Algeria, Libya, and Ecuador all receive substantial revenues from oil production. All of these countries are also projected by the International Monetary Fund to run fiscal deficits in 2015 and 2016. Outside of Saudi Arabia and Russia, any potential voluntary reductions in crude oil production would result in lower revenue and higher fiscal deficits. Given Saudi Arabia and Russia's public statements preferring not to lower production during this time of low oil prices, most national oil companies have the financial incentive to keep producing at current levels.

QUESTION FROM SENATOR ELIZABETH WARREN

- Q1. In recent years, Federal agencies have entered into several large settlements with big financial institutions such as JPMorgan that have been accused of market manipulation in energy markets. Do you see evidence of market manipulation in energy markets today?
- A1. EIA does not have regulatory authority over energy markets. The Federal Energy Regulatory Commission (FERC) and/or The U.S. Commodity Futures Trading Commission (CFTC) are the Federal agencies focused on monitoring potential energy market manipulation.

Overall trading volume and open interest for Brent and WTI futures contracts, traded on the InterContinental Exchange (ICE) and New York Mercantile Exchange (NYMEX), are somewhat higher than at this time last year. However, the combined number of long and short positions of money managers in these markets, as measured by the weekly Commitment of Traders Reports released by CFTC and ICE, is similar to year-ago levels. This implies that the growth in these futures markets is not coming from financial market participants such as investment banks and hedge funds. The lower level of relative participation by money managers also suggests they may have a reduced role in price discovery. The open interest, trading volume, and positions by money managers in natural gas futures contracts traded on NYMEX are all similar to year-ago levels.

EIA's data collection and analysis of crude oil and petroleum product markets indicate that supply and demand fundamentals have a key role in driving current low prices and high volatility in these markets. Estimates for global inventories show that production has been higher than consumption for five straight quarters and are not projected to balance until the second half of 2017. High levels of uncertainty also exist in the markets due to risks to future global economic growth and how fast U.S. and other non-OPEC production responds to low oil prices.

Similarly, for natural gas, moderate temperatures this winter across much of the United States are contributing to reduced demand, higher inventory levels, and lower overall prices. Additional pipeline infrastructure, particularly to parts of the mid-Atlantic and Northeast, is helping to reduce regional price volatility in these areas.

**U.S. Senate Committee on Energy and Natural Resources
January 19, 2016 Hearing: The Near-Term Outlook for Energy & Commodity Markets
Questions for the Record Submitted to Mr. Antoine Halff**

Question from Ranking Member Maria Cantwell

Question: How do you expect lifting of the oil export ban will affect the transportation of crude oil throughout the country, particularly by rail?

Response: The lifting of the oil export ban will likely have only limited effect on U.S. crude shipments by rail or otherwise unless U.S. crude grades become sufficiently discounted versus foreign grades of similar quality to warrant exports. If the spreads widen and exports do pick up, the picture gets murkier. The effect in that case will likely partly depend on other factors such as the overall trend in U.S. crude production. Flat production would mean a zero-sum game where increased crude shipments from Midwestern production centers to Gulf Coast export terminals come at the expense of rail shipments to Atlantic seaboard refineries. Under the right circumstances, however, the opening up of export outlets for U.S. crude could incentivize domestic production enough to minimize the effect on domestic rail shipments.

Rail movements to the west coast would in any event be less subject to change as west coast refiners have fewer supply options than those on the east coast.

Question from Senator Steve Daines

Question: I understand that estimates for national oil company production range between 60 and 75 percent of world production and national oil companies hold between 80 and 90 percent of world reserves. Do we know what the typical fixed and variable cost mix is for national oil companies? Do you believe national oil companies have an incentive to produce oil regardless of the international benchmark price as long as their variable costs are covered?

Response: Not all national oil companies are alike, so I would hesitate to speak of a typical cost mix for NOCs. Most companies have an incentive to produce oil as long as their variable costs are covered, and NOCs are no exception.

**U.S. Senate Committee on Energy and Natural Resources
January 19, 2016 Hearing: The Near-Term Outlook for Energy & Commodity Markets
Questions for the Record Submitted to Mr. James Lucier**

Questions from Ranking Member Maria Cantwell

Question 1: What are your expectations for energy storage and how will that affect electricity markets?

At a high level, development and deployment of more energy storage technology would undoubtedly be a “game changer” innovation in the electricity industry. For the more-than century-long history of electric generation, transmission and distribution, the central problem with electric energy is that it is difficult to store in large quantities over a large period of time. Electricity supply and demand must balance instantaneously to preserve the technical integrity of the grid. As a consequence, electric infrastructure must be built to serve the peak. Widespread deployment of advanced and economical energy storage could obviate this requirement.

With storage, variable, intermittent, and even off-peak resources—including wind and solar at both distributed and utility scale—could be aggregated into dispatchable power and could be managed from the edge or the core of the grid as needed.

However, we are far way away from significant deployment of advanced storage technologies like large-scale batteries. According to the DOE’s Global Energy Storage Database, there are only approximately 470MW of operational peak capacity of non-hydro, non-thermal energy storage deployed across the United States today. The total peak capacity of operational U.S. storage, according to the same database and including thermal and hydro pumped storage is approximately 21GW. This compares with over 1,000GW of nameplate coal, natural gas, nuclear, hydroelectric, wind and solar capacity in the U.S, according to the Energy Information Administration.

Public and private funding for research and development into advanced energy storage technology is fledgling. According to the Energy Storage Association trade group's most recent "U.S. Energy Storage Monitor" summary document, \$265 million of new private investments in U.S. energy storage was disclosed inclusive of the third quarter of 2015; similar data collected by the ESA for each year going back to 2010 ranges from approximately \$200 million to just over \$600 million. While this excludes investments in battery materials and "upstream" industry component companies (as well as undisclosed deals) and is material, it compares with U.N. Environment Programme estimates of U.S. investment in renewable energy projects - often themselves using emerging technologies - of at least \$35.1 billion or more annually since 2010.

Costs for advanced storage are also still significant. One investment bank analyzing the levelized cost of storage - a measurement of lifetime fixed and variable costs computed using assumptions about cost of capital, capital structure and resource-use profile - for an array of energy storage technologies has found that the unsubsidized levelized cost of some storage resources, such as compressed air, pumped hydro, and the most cost-effective lithium ion batteries is comparable only to expensive gas peaker plants. Storage resources are still not cost-effective replacements for traditional baseload central power stations.

**U.S. Senate Committee on Energy and Natural Resources
January 19, 2016 Hearing: The Near-Term Outlook for Energy & Commodity Markets
Questions for the Record Submitted to Mr. James Lucier**

In spite of a continued need for basic research that would lower storage costs and improve the ability to integrate storage with today's grid, there are some meaningful amounts of storage planned in the country's organized wholesale electricity markets, with those markets introducing new tariff designs to incentivize storage development. In 2014, two-thirds of new storage capacity deployed was located in PJM, according to research and media firm GTM; the growth has been attributed to a suite of design changes enacted in 2012 improving compensation for fast-start resources like batteries in PJM's frequency regulation services market. California and Oregon are implementing new out-of-market storage procurement directives to their regulated utilities that would effectively rate-base new storage investments.

Efforts to reduce cost by consolidating the supply chain and achieving economies of scale, such as the Tesla Gigafactory, are perhaps the most exciting efforts in the space.

Storage resources, from older hydroelectric pumped storage to the advanced batteries still in the planning stages, have a role to play in providing valuable grid services in addition to smoothing peak vs. off-peak electricity price volatility. Storage resources can participate in ancillary services markets for contingency reserves, frequency regulation, and grid flexibility services.

But before policymakers, regulators, market operators, and regulated and unregulated utilities alike implement policies that would encourage or even require immediate deployment of new storage, careful attention must be paid to the implications of such a deployment to the reliability and integrity of existing systems and markets.

Is storage properly a "utility-scale investment" made by regulated utilities? Or does it blur the line between regulated transmission and merchant generators putting these two complementary services in competition? Does every home need a Tesla Powerwall? Is some form of storage a logical component of all renewable installations, whether distributed or utility scale?

The old model of power pushed one way from central generating stations is long gone. The dominant model remains one of command and control dispatching power in organized markets. Storage and distributed generation combined with the digital grid point to a new decentralized, market-style model with metered payments and multidirectional flows of power and information.

**U.S. Senate Committee on Energy and Natural Resources
January 19, 2016 Hearing: The Near-Term Outlook for Energy & Commodity Markets
Questions for the Record Submitted to Mr. James Lucier**

Question 2: How and why have the business models for electric utilities been evolving? How do you expect that to continue in the next year?

Challenges to Utility Business Models

From the opening of Thomas Edison's Pearl Street Station in 1882 through the heyday of Samuel Insull in the 1920s and well into the post-World War II era, the prevailing business model for investor-owned utilities rested on two assumptions: economies of scale, and presumed natural monopolies. A regulated rate of return on large fixed capital investments made it possible to secure private financing for these otherwise risky experiments. The system was not perfect. On the one hand, through the phenomenon of regulatory capture, where regulators identify with the interests of the industry they regulate, and risk-averse elected officials prefer to be safe rather than sorry, it is arguable that cost-based regulation has a long term tendency to over-investment. On the other hand, the efficiency gains available through scale economies kept consumer prices steadily falling in real terms throughout the era.

The system began to reach its limits in the 1970s, when large nuclear and coal-fired power plants and the transmission infrastructure needed to support them became increasingly expensive and difficult to site. The scale economies also began to run out. The decade of the '70s became known for cost overruns, most notably on nuclear projects, utility bankruptcies, and rate shocks. At the same time, wide reserve margins suggested that existing generation plants were under used.

One response at the federal level was the Public Utility Regulatory Policies Act (PURPA) of 1978 which promoted co-generation and allowed non-utility generators to connect to the grid and sell power for avoided costs as an alternative to meeting public needs through large, central power plants. Meanwhile the states looked for their own strategies to manage costs through improved rationalization. In the 1980s, "Integrated Resource Planning" (IRP) became the watchword of the day, while in academe pioneering researchers began to postulate a competitive market in generation services. The combined cycle gas turbine, long in development, fortuitously emerged from the aerospace world at this time to make competitive markets a reality.

Combined cycle gas offered high levels of efficiency at relatively low cost, in conveniently small, modular units that could be manufactured in large numbers. Combined cycle also offered low emissions and could be installed near load, still requiring transmission, but not nearly as much as purpose-built coal and nuclear baseload plants far from city centers. Capital costs were low, and as long as the price of natural gas was low as well, electric power could be cheap. Industrial users began lobbying states and Congress for access to this low cost power, outside the comparatively expensively regulated framework. In part with the model of FERC's Order 636 deregulating natural gas pipelines, Congress and FERC responded with the Energy Policy Act 1992, which established a class of "exempt wholesale generators" and FERC's landmark Orders 888, 889, and 2000 which helped establish competitive wholesale markets for power in the ISOs and RTOs which serve about two-thirds of the American public today.

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On the state level in the 1990s, momentum grew for unbundling the generation, distribution, and transmission services historically offered by vertically integrated utilities and restructuring state markets into, theoretically, competitive retail services, regulated transmission and distribution (T&D) services and competitive wholesale markets for power. The political impetus for restructuring was linked to natural gas prices: the cheaper gas was, the more industrial users wanted “market power” as an alternative to regulated rates. By the late ’90s the state struggle had come to Congress, and in the early 2000s terms like “mandatory unbundling,” “participant funding,” and “stranded assets” were the battle cries of opposing interests. But with the California power crisis of 2000 and 2001, the state-level momentum for restructuring came to a halt, and after the failure of a proposed “Standard Market Design” at FERC, the Energy Policy Act (EPACT) of 2005 helped codify an uneasy status quo. About that time, too, companies like Enron and Mirant, which had seemed like unstoppable heralds of the future, went bankrupt, and Wall Street’s smaller echo of the dot-com boom in building gas-fired power plants came to a halt.

Combined-cycle gas installations peaked in the dot-com era.

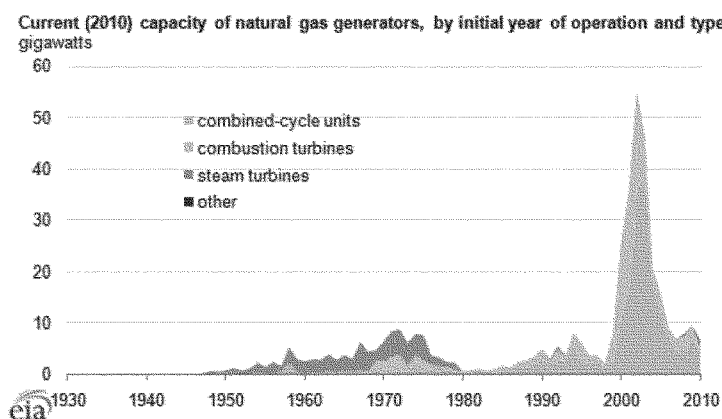


Image Source: Energy Information Administration (EIA), July 5, 2011, Today in Energy, <http://www.eia.gov/todayinenergy/detail.cfm?id=2070>

The seven major competitive markets in RTOs and ISOs did not stretch from coast to coast, as some envisioned, but where they were established they proved highly effective in making more efficient use of state generation portfolios and allowing regional planning for more efficiency gains. The nuclear renaissance of the 1990s and early 2000s is in large measure a success story made possible by competitive wholesale markets for power. However, just as cost-of-service regulation has an arguable bias toward “over-investment” (meaning investment levels higher than a pure free market might generate but possibly consistent with keeping jobs and revenue in

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state, as well as providing an extra margin of reliability that prudent state government officials might deem appropriate), the “scarcity-based pricing” used in the wholesale markets can have the opposite effect. The bias in such a pricing scheme drives prices down toward that of the lowest marginal cost provider, ultimately allowing no return on equity and in extreme cases, limiting prices to variable costs only. Such a scenario has been on display with the sudden and sustained drop in natural gas prices due to the shale revolution. Further, unless carefully designed, constrained energy only-markets may fail to correctly value reliability and ancillary services, the economics of which are not necessarily reflected in an energy only price.

FERC and the major organized markets, led by the PJM RTO, have shown a solid decade’s worth of attention to this problem. PJM and ISO-NE are both well along in establishing a “Pay for Performance” or “Capacity Performance” type construct which does provide enhanced economic support for reliability. FERC is also conducting an inquiry into price formation in the energy markets, which we regard as constructive. However, this alone does not address the problem of retiring baseload. In practice, capacity prices have failed to provide a signal for new investment in next generation baseload or the maintenance of existing, relatively high-cost baseload. In PJM for example, they provide a price for capacity for only one year, three years into the future. Accordingly, the markets are studying longer-term mechanisms as well, but progress is slow.

Even more fundamentally, a market based on scarcity pricing does not well-accommodate zero marginal cost resources, such as renewables, without driving down the clearing price for everything else. The classic case of this occurs when intermittent, variable wind resources with zero marginal cost and support from the wind power production tax credit appear on the dispatch curve prior to baseload nuclear, forcing the nuclear power plants to operate below capacity, and even, in effect, to cycle inefficiently for less revenue than they would have received in a market without the zero marginal cost supply.

Finally, the principle of economic dispatch in wholesale markets as currently structured is not consistent with the principle of environmental dispatch called for in the Clean Power Plan.

The practical uncertainty over the manner in which wholesale markets and market participants will weather the era of low prices and and accommodate not just renewables but energy efficiency and storage has hurt investor confidence and prevented an industry consensus from arising on what ideal competitive markets look like. Some speak of “Competitive Markets 2.0” in which there are separate procurements for energy efficiency, demand response, and the like. Others speak of regional “Super IRP” with procurement along the same lines. All the while, states continue to press for out-of-market solutions, as we see currently in Ohio, Maryland, and New Jersey.

Our main conclusion is that concern over utility or electric power business models is properly a concern for competitive wholesale suppliers. Regulated utilities do face competition for incremental power demand from renewables and other resources in a declining, flat, or slow growth environment, but their cost-based regulation gives them recourse to the rate base, and the

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Clean Power Plan offers the prospect--to some, at least--of increasing the rate base by investing in utility-scale renewables, new gas-fired power plants, cyber security, weather resiliency, and energy efficiency technologies. Regulated utilities have been wrestling with the concept of rate decoupling for over 30 years, beginning with California's program in 1982. It is not inherently new.

The notion of intelligence and dispatchable power at the edge of the grid is not new either. In the 1990s and early 2000s, it meant diesel gen-sets and Capstone microturbines fueled by natural gas. But now distributed renewables and the promise of storage offer a way to make intermittent, variable, and occasionally off-peak power at zero marginal cost dispatchable as well. This raises many interesting questions about business models and pricing that can be answered only through market competition. End-to-end reintegration of the power industry seems highly unlikely at the moment, despite such technologies as Big Data, the Internet of Things, not to mention ubiquitous Internet Protocol-based sensors and controls that would make such re-integration possible. Rather the future seems more likely to be a mixture of regulated and competitive market participants in a diverse variety of forms.

From a historical perspective, we see a continuous search for the silver bullet, whether it be nuclear power so cheap it would not be metered, PURPA-style Qualified Facilities delivering power at "avoided cost" that turned out to be higher than other alternatives, full-blown unbundling, merchant transmission companies, or the latest new idea. Policy makers naturally look for the lowest cost, most expedient solution to meet immediate needs, even if, as with QFs, it does not represent a viable long term investment strategy. Similarly, rent-shifting or cross-subsidization from one industry to another is a recurrent theme, as Congress saw in past debates over participant funding, network upgrades, and socialized costs in the electric debates transmission of 15 years ago. Future market evolution will depend on reasonable cost allocation, accurate price discovery, and the principle that each new mode or technology, so much as possible, pay its own way in the competitive marketplace.

Reasonable policy principles for market driven evolution going forward might be as follows.

- Reliable and affordable electricity is of paramount value in the modern economy and an essential public service.
- Policy must incorporate a holistic, long-term view to support a diverse variety of options.
- Policy must be stable and predictable, in a framework open to market-driven change
- Policy makers should avoid subsidizing any one technology, business model, or financing tool--with reasonable approaches to cost sharing and cost-allocation where appropriate.
- Policy makers should communicate clearly their commitment to viable wholesale markets and adequate returns on infrastructure investment.

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- Policy makers should seek first to do no harm--since the consequences of errors can last for decades.

Question 3: In light of the electric utility consolidation trends in 2015, state and federal oversight is more important than ever to protect consumers. Is this consolidation trend expected to continue throughout 2016?

Electric utilities, and utilities generally, have historically been very capital intensive, and consequently the industry globally exhibits a long-term trend toward consolidation, as companies are keen to take advantage of economies of scale. (See my remarks on utility business models in my supplemental testimony.)

But the electric utility industry in the United States is relatively fragmented compared to that in other countries. In 1935, Congress passed the Public Utilities Holding Company Act. With this legislation, which restricted consolidation in the industry, the U.S. made a policy choice to steer utility corporate structure to local or regional monopolies. Most countries have only one or a handful of national power companies. In the United States, there are 189 investor owned utilities, over 2,000 public power entities, nearly 900 co-ops, 9 federal agencies, and 218 power marketers.

While PUHCA was repealed with the Energy Policy Act of 2005, its effects on the corporate structure of the American utility industry are still felt. The Edison Electric Institute, the association of shareholder-owned electric utility companies, counts 69 investor-owned companies as its members, a much higher number compared to most OECD countries.

With the repeal of PUHCA, cheap financing given the low-interest rate environment, and absence of organic earnings growth, utilities in recent years have been driven to consolidate. But consolidation is selective; market conditions have divided utilities into “haves” and “have-nots”. The “haves” approach M&A with strong cash flows, liquidity, and healthy balance sheets. They are buying, at a premium, earnings growth and stability from smaller regulated utilities well-positioned to make rate-based investments but in need of a broader capital platform. The “have-nots” are the utilities missing out on M&A. They do not have the reserves and cash flows to engineer growth through acquisitions in the face of secular organic demand stagnation. “Have-not” non-targets are the companies with risky assets no one wants to buy.

I expect industry consolidation to continue to be selective into 2016. Volatility in the capital markets means only the most pristine acquirers will be able to line up financing for deals or otherwise pay out of pocket from ample cash reserves. Targets will continue to be only those utilities - frequently electric as well as gas regulated distribution companies - with visible growth trajectories and stable, constructive regulatory outlooks.

In the unregulated electric power side, I expect that future M&A will also be selective and similarly geared towards acquisitions of generator assets and companies with competitive cost structures and in constructive regulatory environments. Private equity investors with deep

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pockets may see value in specific assets. But this assumes that any merchant companies have balance sheets that can support acquisitions and access to financing, both of which seem unlikely at the moment given the current state of the industry and the high yield debt markets.

Please note: Capital Alpha Partners, LLC is not a registered investment adviser, does not make investment recommendations, and does not advise clients on M&A activities. The following remarks are offered as general, high-level commentary based on public information only and only in response to this specific question.

Question from Senator Steve Daines

Question: I understand that estimates for national oil company production range between 60 and 75 percent of world production and national oil companies hold between 80 and 90 percent of world reserves. Do we know what the typical fixed and variable cost mix is for national oil companies? Do you believe national oil companies have an incentive to produce oil regardless of the international benchmark price as long as their variable costs are covered?

We are unable to answer the Senator's question at this time.

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Questions for the Record Submitted to Mr. Ethan Zindler**

Questions from Ranking Member Maria Cantwell

Question 1: What are the primary drivers for the increased deployment and investment in clean energy?

Question 2: For clean energy investments, how have the trends changed for where the investments are coming from and how they are being spent?

Question 3: Can you discuss where across the country renewables are already competing directly based on price with fossil fuel generation? How will that change over the next few years?

Question 4: What are your expectations for energy storage and how will that affect electricity markets?

Question 5: While testifying, you stated that you could “submit for the record Department of Labor statistics on green energy jobs verses fossil fuel jobs just to show the growth and amazing surpassing of that sector.” Please submit those statistics for the record.

Question from Senator Bill Cassidy

Question: In areas of high electricity, such as California, to what degree is the distributed energy sector actually natural gas as opposed to solar or wind?

As of the date of printing, no responses to the Questions for the Record above have been received from Mr. Ethan Zindler.

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Questions for the Record Submitted to Mr. Daniel McGroarty**

Questions from Ranking Member Maria Cantwell

Question 1: To what extent, during a major down cycle for metal and materials commodities like we are experiencing now, are recycling or alternatives available to fill in for a reduction in active mines?

Thank you for the opportunity to answer these questions, and contribute to the Committee's thinking on critical materials policy.

This is in fact two questions, as the answer will differ substantially for recycling and for alternatives.

Recycling. Recycling can and should contribute to "bridging the gap" for reduced production of various metals during a production down-turn. In fact, recycling should become a regular feature of metals and minerals supply *as such* -- across all economic cycles.

The same is true for reclamation -- a sub-set of recycling, but meant here specifically to refer to reclaiming valuable metals and minerals from mine tailings and so-called "waste piles." This is win-win: for the environment and for the economy, as the U.S. would see a clean-up of old mining sites (in some cases removing them from a very long list of dangerous sites) while creating an incentive for metals-suppliers to effect the clean up. In fact, a comprehensive study on the potential for rare metals reclamation, with recommendations on federal policies that could encourage reclamation, would be a valuable tool for Congressional policymakers.

Alternatives. As for relying on alternatives to bridge down-cycle gaps, I have to say that this is problematic. Whether we are looking at high-tech, clean-tech or advanced weapons systems, specialized systems that rely on engineered metals and minerals cannot easily substitute "alternative materials."

First, as I indicated in my testimony, it is all too often the case that substituting for a specific scarce mineral simply creates a new dependency on another equally or even more scarce metal -- such is the case when the U.S. is so deeply dependent for 47 metals and minerals.

Second, sophisticated systems are designed, qualified and tested with very exacting materials characteristics being essential to functionality and reliability. To substitute an alternative would require a re-certification, and perhaps a re-design; a re-design would trigger a need to re-engineer the production line. These are lengthy and extremely expensive processes -- ones not lightly undertaken when the outcome is uncertain. There is no "flip the switch" solution here.

If in addition we shorten the time-frame -- in effect, looking at alternative metals and minerals during a commodities downturn like the present -- we compound the difficulties. Current processes and production lines represent "sunk costs," which companies will be reluctant to abandon for new processes. If any policy is to help here, it would have to be very "durable" --

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not subject to short-term change or reversal – to have even small hope of encouraging companies to experiment with alternative materials.

Consider what it means, practically speaking, to substitute for a scarce material: Will switching to a new metal impair the functionality of my smart phone? What if the “product” is not a smart phone but a smart bomb – what steps will be required before an alternative material is qualified and deemed acceptable? What about the process for introducing a new alloy into a jet turbine? What about the same for a jet turbine on a fighter aircraft?

Materials science R&D changes quickly, constantly. But turn to the industrial use of materials, and change is fraught with challenges, unexpected costs and consequences.

Any discussion of alternatives or substitute materials should be informed by these realities.

Question 2: What more, if anything, should the government or industry be doing to support research into new alternatives or recycling opportunities?

In the case of research into **alternative or substitute materials**, U.S. policymakers would be best served by a case study of one or more efforts to substitute materials in an ongoing manufacturing process. This would illuminate the cautionary points made in my previous response.

In the case of **recycling** (and by extension, **reclamation**, as discussed above), we are past the point of research, and should be focused on demonstrations and/or pilot programs that would shed light on:

- specific methods of recycling/reclamation;
- associated costs;
- efficiency of recovery of imbedded metals/minerals; and
- process improvements applicable to all of the above.

While federal spending in the current climate is severely constrained, the return on program dollars in these instances – with many demonstrations requiring expenditures ranging from the low- hundreds of thousands of dollars to single-digit millions of dollars – could save billions in federal clean-ups (in the case of reclamation of mine wastes) and open up reliable sources of “new” metals and minerals (in the case of recycling) currently being consigned to trash dumps.

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