

# **Center for Strategic and International Studies**

## **“EIA’s International Energy Outlook 2017”**

**Featuring:**

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FRANK A. VERRASTRO: (Off mic.)

IAN MEAD: OK. Thank you for that introduction. Firstly, I wanted to say good morning to everyone. I'm happy to be here. Before I delve into the presentation, just because we've got a diverse audience out there, I'll mention just a few words about EIA's mission and what we do, and then I'll delve into the presentation, which I'm sure you're all eagerly anticipating the results of.

So EIA is the statistical and analytical agency within the department of energy. What we do is we collect, analyze, and disseminate energy information in an impartial and independent way. We do this in order to promote sound policymaking, to increase efficiencies in markets, and educate the public about the role of energy, how it interacts with the economy and with the environment as well.

The scope of what we cover is very diverse. It not only includes but it also includes end uses and flows between sectors. And in addition to the data collection and dissemination efforts, we do a regular set of weekly, quarterly and annual reports. We even have a daily "Today in Energy" article as well. So in addition to those analytical reports, sometimes we do special reports. But in addition to those analytical reports, we also have a short-term energy forecast that's produced on a monthly basis. We just came out with that a few days ago. We do an annual energy outlook which we released in January of this year.

And today what I'm going to talk about is our international energy outlook. And what these outlooks do is they present long-term projections. In this case, what I'm going to talk about to, out until 2040. So in terms of the presentation itself – oh, does this – OK. I can see right here. Great. OK.

I'm going to start out with the key takeaways. I'm going to talk a little bit about the uncertainty inherent with long-term energy projections, and talk about what's new for this IAO in terms of the time period covered, at least with our detailed data on the table browser on EIA's website, and what we're going to follow up this annotated slide deck that's being released this morning with. And then I'll dive into the more detailed results.

So starting out with the key takeaways. World energy consumption increases from 575 quadrillion Btu in 2015 to 736 quadrillion Btu by 2040. This represents a 28 percent increase with more than 60 percent of the increase energy consumption coming from non-OECD Asia, which includes China and India. More than 60 percent of the increase in energy consumption comes from China and India. And if you look at the sectors of where the demand is, the industrial sector still accounts for over 50 percent of delivered energy consumption in 2040, despite the fact that we see higher growth in the demand for residential – in the – demand in residential and transportation sectors.

Transportation energy use rises by nearly 30 percent over the projection, with almost all the growth occurring in non-OECD regions. There are two components to this growth. The first is personal transportation services. As incomes rise in many of these non-OECD regions, we expect greater demand for transportation services. There also is a freight component associated with this, that in order to meet the needs with rising standards of living that more shipping is needed, more transportation is needed in order to get goods and services to final customers. And for the producers of these countries as they become more further integrated into the global supply chains, more transportation is required in that aspect as well.

Turning to the supply side, we see renewable energy being the world's fastest-growing energy source, increasing an average of 2.8 percent a year over the projection period. To put that in a bit of perspective, nuclear energy is the second-fastest growing source, at 1.5 percent, and liquid fuels only increases by 0.7 percent, on average, a year over the period. Despite this large growth in renewables, fossil fuels remain dominant. And at the end of the projection, they continue to supply about three-quarters of the world's energy needs.

Out of fossil fuels, natural gas is the fastest-growing fossil fuel, with global consumption increasing an average of 1.4 percent a year. Turning to coal, coal use remains flat over the projection period as declines in China are largely offset by increases in India and other parts of Asia. Finally, turning to world energy carbon dioxide emissions, these are projected to grow by 0.6 percent a year, on average, which is much lower than the 1.9 percent growth rate that we were seeing over the period of 1990 through 2015.

So turning to the uncertainty associated with the projections, one of the ways we try to address this and remind people that there's inherent uncertainty associated anytime you do long-term projections, is we provide side cases. For those of you familiar with the AEO, they're very rich, robust side cases. In the IEO they're a bit more limited. Nevertheless, we do look at side cases when it comes to total energy consumption and fuel shares as well.

In IEO the two sets of side cases we typically look at are high and low economic growth and high and low oil prices. The high and low economic growth cases speak to the uncertainty associated with increases in demand due to higher growth rates across the world. The high and low cases speak to the uncertainty associated with energy prices as we move forward.

For the economic growth case and the reference case, which is what I'll spend most of the morning talking about, we're assuming that the world economy grows at 3 percent a year. And in the high and low economic growth cases, we're assuming 2.7 versus 3.3. So that represents a 10 percent difference in terms of our growth assumption for the world economy.

For high and low oil prices in the reference case we're assuming that the price of Brent crude in constant 2016 dollars reaches \$109 a barrel by the end of the projection period, in 2040, compared to \$226 a barrel or \$43 a barrel in the high- and low-price cases. I'll talk a little bit about these cases when we get into more detail in the presentation, but, as I said, most of the results I present will be the reference case this morning.

Turning to improvements we've made to the IEO this year, one of the things we've done is this is the first year that we're including modeling results all the way through 2050. So we've extended the period of our projections by 10 years. I am going to focus mainly on the projections through 2040. The reason that we do that – do it that way is what we're asking is for people to comment on those last 10 years' worth of our projections. A lot can happen over that period and we want to solicit customer input before we start highlighting them in our main publications.

We did this with the AEO. It seemed to work well. We got a lot of nice feedback that helped us kind of improve our modeling. We'd like to do the same thing with the IEO as well. The expectation is next year after we solicit feedback from users, we'll be able – or we'll highlight the results all the way through 2050. Even though I'm not highlighting them today, they are available on our webpage. Another improvement that we're making is we're coming out with a new publication format that's more consistent with – or, is consistent with what we did with the IEO this year. It's a

flipbook. I think it's much easier for people to find information and highlights the key findings. We've gotten a lot of positive feedback on it.

What's going to be different about the rollout of the IEO is that we are going to be following up with four bonus articles or four issues in focus, unlike with the AEO. Two of these issues in focus are going to relate to the uncertainty inherent with our projections. One of them is going to focus on penetration rates for electric vehicles. One of the big, positive developments this year is we have a new international transportation demand model. And what we're going to do is have an issue and focus that looks at changes in consumers' tastes and preferences, with different penetration rates and how they affect supply conditions.

Another one that relates to uncertainty is growth in China and India. Even though we've got these high and low economic growth cases, it's really important where that growth occurs and how it occurs. We might not get as far as we want, but at least we want to start setting the stage. And we're going to have an issue and focus that looks at different growth rates for China and India to see what affects they have on total energy consumption.

Turning to our modeling assumptions, we're going to have one issue and focus that deals with the Paris Agreement and the NDCs. What we're going to do in this issue and focus is – it's a complicated topic, in the sense that it doesn't directly translate to energy modeling. What's in the Paris Agreements is much broader than what we cover, but at least it's incumbent on us to explain what assumptions we're using in the model. There isn't a perfect, direct one-to-one correlation. But we do want to make it clear to people how the recent developments associated with those influenced our thinking in the outlook. So – and then the last one is going to deal with our assumptions related to upstream oil and gas.

So turning to the results, I said one of the key takeaways was that world energy consumption rises by 28 percent over the projection. This can be seen in our outlook in the three right bars on the graph. And if you look at the red, that's the growth in energy consumption by non-OECD countries. That increases from 335 to 474 quadrillion Btu, or 41 percent, over the projection. If you look at the blue bars, which represents OECD countries, you do see a slight increase there as well. But that's only a nine percent increase from 239 to 262 quadrillion Btu.

Digging into the details of non-OECD countries, if you look at the red that represents Asia. Energy demand in non-OECD Asia is projected to increase 51 percent or 102 quadrillion Btu. Although this growth rate is much less than the 3,000 – or, I'm sorry – the 300 percent increase we were seeing over the period of 1990 through 2015, it still is a rapid growth rate in energy consumption. That's not all of the story. We do see rapid growth in the Middle East and Africa, which are in brown and yellow. In Africa, we see energy consumption increasing by 51 percent, in the Middle East 45 percent, but Asia is a much larger market and it drives many of the results.

The slowest growing in terms of energy consumption is non-OECD Europe and Asia, which is in blue. What's going on there mainly is a story about Russia. We expect declining population over the projection period. And not only that, we expect gains in energy efficiency as older equipment is replaced by newer and more energy efficient stock.

What's driving the results? There are a number of things that affect energy consumption, but one of the main drivers is economic growth. If you look on the right, we've got the growth rates that we're using in the outlook for non-OECD countries. And the first thing that you'll notice is that India

and China are right at top with average annual growth rates of 5 percent and 4.3 percent a year. If you go down to the bottom for the growth rate for total non-OECD countries, we're seeing those grow at 3.8 percent over the period. Heading directly over to the OECD countries, you can see that's more than twice the rate for OECD countries, which are expected to grow only 1.7 percent over the period.

I will mention something about Japan, because I'm going to use it in an example later. We've had a very slow average annual growth rate of only 0.2 percent over the year. That's mainly due to demographics as the population declines and as the workforce – or, as the workforce ages. Turning to the uncertainty, if you focus on the last three bars – and I'll start by looking at the top, the reference case versus the low and high economic growth cases – the variation between those ranges between only about 4 and 5.5 percent.

This is one of the things we'd like to improve or at least make more robust going forward. That's not that great of a range. As I said, it really depends on where – you know, we mainly do this at this point in time to remind people there's a lot of uncertainty. And this is a lot of the reason that we're developing an issues and focus associated with growth in India and China. But that does at least say something about the sensitivity of our results, at least with some very simple assumptions about differences in growth rates in the world.

Turning to the uncertain associated with prices, on the left I've got what's being used in the model – the high-oil-price, the reference, and the low-oil-price price paths. What I'm going to mainly focus on is what's on the righthand of the slide, which is the resulting world energy consumption that's coming out of our projections. Before I discuss the results, I do want to mention something about how we put this case together to cut off a little bit of confusion at the pass.

When you're talking about the closed world economy, in order to get those high oil prices you not only have to tighten supply conditions, but you have to have higher economic growth. And this explains why in the high oil price case the top of that bar in 2040 is actually higher than that in the reference case. You do see in higher oil prices fuel switching. There is some incipient pressure to limit economic growth.

But what we see in our high oil and low-price cases is the increases in growth and the demand overcoming and being much more strong. What you do see, though is a narrowing of that range because you both – now you not only have the demand factors, but you have some supply-related factors in there as well. We do see some fuel switching between liquids and other forms of energy. And that switching is on the order of about 3 or 4 percent between the cases.

Another key takeaway was the industrial sector continues to account for the largest share of energy consumption in 2040. That can be seen with the orange bars. Energy consumption in the industrial sector increases by 0.7 percent a year on average as you go throughout the period. Most of that comes from non-OECD countries. In fact, about 90 percent of it in non-OECD countries. The growth rate in the industrial sector is 0.8 percent, compared to only 0.2 percent a year for OECD countries. You can compare that to transportation in blue, which is projected to increase by an average of 1 percent a year. And buildings, in green, which is projected to grow by 1.1 percent a year.

Turning to fuels, I had made the claim that fossil fuels will remain dominant by the end of the projection period. You can see that by looking at the top line, which is petroleum and other liquids, which does grow over the period by that 0.7 percent a year that I mentioned. And you can also see that by the growth of natural gas, which is shown in blue, the fastest growing fossil fuel, at 1.4 percent.

You see that dramatic increase in renewables of 2.8 percent a year. And what you can also see is the growth in nuclear and the fact that coal declines only slightly, that it's relatively flat, unlike history.

Turning to energy-related carbon dioxide emissions, if you look at this graph in the red, the rate decreases. Much of that decrease in the right comes from non-OECD countries. A lot of it is due to fuel switching in the electricity sector. We're seeing strong growth in transportation demand in non-OECD countries, which lead to more carbon dioxide emissions. But what we are seeing is a growth in the share of renewables and the use of natural gas and electricity generation. That's the big change. Carbon dioxide emissions remain relatively flat in terms of the rate going forward. And the main story is related to non-OECD countries.

Now, one of the things you can do to talk a little bit more about this topic is you can actually relate carbon dioxide emissions to economic growth. We're seeing large – or expecting large growth in non-OECD Asia and other non-OECD countries. Those are mapped out in the first two panels. And the way that you can relate that to carbon dioxide emissions is think about energy intensity and carbon intensity.

So one way that you can lower the rate of emissions with the same level of production or growing production is to actually use less energy in the production of those goods and services. So what energy intensity measures is the amount of energy that's needed to produce, you know, a dollar's worth of final goods and services in the economy. And one way you can get reduced emissions is actually to be able to produce those goods and services using less energy.

Carbon intensity speaks to the fact that for that unit of energy you need to produce a final good and service, you can actually produce it in a way that provides less carbon dioxide emissions. And what you see is one of the big changes here, is that energy intensity – both in non-OECD and OECD countries – has been decreasing for a while, in both sets of regions in the world. But what's different going forward is that the carbon intensity associated with the non-OECD world is dropping.

Digging into a little bit of country-level detail, I'll focus primarily on China and India and I'll mention something about Japan. The orange bars show per capita GDP and the blue bars show energy intensity. In the cases of China and India, we have those large increases in GDP. We have that rising standard of living, which is roughly measured by per capita GDP. But we're also seeing large decreases in energy intensity, which are at least scaling back a little bit the amount of energy consumption that would be typically be associated with those higher levels of GDP if you didn't have those gains being made.

Japan's an interesting case, in the sense that almost nothing is going on there. I had mentioned that Japan was only expected to grow about 0.2 percent a year. We're not seeing large increases in energy intensity because Japan already is one of the most energy efficient countries in the world. So Japan remains relatively flat on all accounts.

Turning to liquid fuel markets, petroleum and other liquid fuel consumption grows by 18 percent over the outlook. And that essentially all is coming from non-OECD countries. In non-OECD countries, economic and population growth causes the demand for liquid fuels to increase by 38 percent. That can be seen in the red. But if you look at the blue, overall OECD consumption of liquid fuel actually decreases by 3 percent. More than 80 percent of the increase in consumption in non-OECD countries comes from non-OECD Asia. And China's use of liquid fuels in transportation is projected to increase by 36 percent of the period.

And India's is expected to increase by 142 percent. And I know that that sounds like a surprisingly large number. A lot of what's going on in India is we're expecting high population growth, high economic growth. And starting from a low base, there are opportunities for more urbanization. So I know – like I said, I know it sounds like a really high number, but, you know, in some sense it's almost the perfect storm in terms of energy use associated with transportation demand.

Turning to the shares, the transportation sector, which is shown in green on the top, remains the largest consumer of refined petroleum products and other liquids. Petroleum and other liquids are also used in the industrial sector to power equipment, service chemical feedstocks, and provide industrial heat. That can be seen in the yellow. They're also used to a limited extent to heat building and, even more of a limited extent, to provide electricity. One of the things that's interesting to note on this graph is that even though the share – or, even though the levels increase over time for all fuels, with the exception of the use of liquid fuels and electricity, even though they increase their shares remain relatively constant over the projection period.

Turning to where these liquid fuels are coming from, initially, in the beginning part of the period, it's coming from other liquids. I'll turn to that in a second. There's a real interesting story associated with that. And then later in the period it's coming from oil production, primarily from OPEC countries.

So the interesting story, as the world produces natural gas there are other hydrocarbons that come out of the streams that are pulled out of the ground. It used to be a case that a lot of these hydrocarbons were either left in the stream or adjustments were made to lower the heat rate so that it was pipe-ready for delivery to customers. What's happened as there's been more natural gas production is well-defined markets have developed for some of the other hydrocarbons. And a lot of investment has been made in order to pull them out and to find uses for them, you know, in terms of providing heat, transportation, or chemical feedstocks.

So the big increase we see in other liquids is in natural gas plant liquids, even though when we talk about liquid fuels most people think about oil. But at EIA, you know, we're talking about liquid fuels at a whole. We're combining these, even though they're coming from natural gas streams, in with the petroleum liquids. And this is a lot of the interesting story and why we're seeing the increase. And it's associated with the increase in natural gas production we see.

Where is the oil coming from? For OPEC countries it's mostly occurring in the Middle East. We don't see much growth in North African, West African and South American OPEC members. And even though non-OPEC crude oil production increases less than 2 percent over the projection, there is some strong growth in a few countries, at least. These countries are Russia, Canada, Brazil, and Kazakhstan.

Starting with Brazil, we expect Brazil to increase its production by close to 2 million barrels – billion barrels a day. Or, I'm sorry, 2 million barrels a day. And most of this is attributable to greater offshore production occurring mainly in the later part of the period. In Canada, we anticipate a 1 ¼ million barrel – barrel a day increase by the end of the projection period, mainly coming from oil sands with small additions from tight to non-tight resources. In Russia expect about a half a million barrel a day increase, mainly coming from conventional resources. And Kazakhstan, we expect the future development of one of the main oil fields in that country.

Turning to natural gas markets, we see consumption increasing both in the non-OECD and in the OECD countries. Natural gas consumption actually grows in every region on the IEO – or, that we consider in the IEO. And non-OECD countries, you can see with the red line, it increases at a much more quicker rate, at an average of 1.9 percent a year, compared to the OECD countries, where it's projected to increase only 0.9 percent a year, on average.

Where is that – which sectors is that demand coming from? It's primarily in the industrial and the electric power sectors. In fact, power and industrial sectors account for nearly 75 percent of the increase in natural gas consumption over the projection. Natural gas-fired generation is attractive for new power plants, because of low capital costs, favorable heat rates, and relatively low fuel costs – which explains the growth seen in the yellow at the bottom. Natural gas-intensive industries – such as chemicals, refining, and primary metals are expected to expand over the period, particularly in non-OECD regions. And that explains the increase in brown for the industrial sector.

We do see a little bit more use of natural gas in transportation. This is related to international agreements on sulfur fuel requirements, limiting the amount of sulfur that can be in fuel in maritime shipping. Some of these rules are going to start taking effect within the next few years. And what we see is certainly towards the end of the period at least some fuel switching, some liquefied natural gas being used as a bunkering fuel. It's not only driven by the new fuel requirements, but also the fact that there's a long enough time period for some of the stock of ships to turn over, and we expect low natural gas prices through the projection period.

Where is all this natural gas going to come from? Primarily from the Middle East, United States, and Canada, which we project is accounting for more than 60 percent of the world increase in natural gas production. In the Middle East, it's primarily from Qatar and Iran. In the United States and China, we expect it to mainly come from the development of shale resources. In Russia, we expect it to come from increased use of resources in the country's Arctic and eastern regions. I will mention, as well, that we do see Africa increasing production as newly developed offshore fields in Mozambique and Tanzania increase production, start coming on – more starts coming online.

Shale and tight gas become increasingly important to gas supplies, not only for the United States but also for China and Canada. And if you look at shale gas for the United States, which is in red on the – on the right, you'll see the growth there. In 2015, natural gas from shale resources in the U.S. was about 50 percent. By the end of the projection period in 2040, we expect 70 percent of U.S.-supplied natural gas to come from shale resources.

Shale resource development also plays an important role in China. You can see that increase in red for China in the middle. And we expect by the end of the period nearly 50 percent of China's natural gas production to come from shale resources. In the case of Canada, future natural gas production is expected to come mainly from tight resources from several regions in British Columbia and Alberta.

Turning to electricity markets, there's a common theme here. You're seeing a greater increase in non-OECD countries. A lot of this is due to increasing standard of livings. There also are a number of these countries, like India, that are making serious efforts to further electrify the country. The growth rate and electricity generation in non-OECD countries is expected to grow 1.9 percent a year on average. That's seen in red. Versus only 1 percent a year on average in OECD countries. If you look at the righthand side, most of the increase in use is expected to be in the residential and commercial sectors.

One thing I will mention is we do see more of a doubling of use of electricity in transportation, but it's starting at a very low base. So by the end of the projections period, delivered energy to the transportation sector is only – still only 4 percent by the end of the projection period.

Turning then to the sources for generation, I'll focus mainly on the righthand side, but I do provide the total levels on – or, on the righthand side. I do provide the total levels on the left. You can see coal, which is in black, getting squeezed out by natural gas and renewables. So we see a large increase in the share of renewables and electricity generation, and in natural gas. So even though coal's share in electricity generation remains relatively constant over the period, as the needs and the generation increases coal constitutes much less a share as it gets squeezed out by those other two sources of generation.

Where is the growth in renewables coming from? Wind and solar dominate growth and represent two-thirds of the related capacity conditions in 2040. If you focus again on the graph on the right, you can see hydropower's share of generation falls from 71 percent to 53 percent in 2040. You see the large growth in solar and wind generation from non-hydro renewables, which include solar and wind, increase an average of 4.7 percent a year. Wind and solar increase the most over the period, reaching 1.5 and 1.4 trillion kilowatt hours by the end of the period.

In terms of the story with nuclear, China accounts for two-thirds of the net increase in world-installed nuclear capacity. This can be seen by looking at the graphs for the non-OECD countries. China is expected to add about 110 gigawatts of capacity over the projection. India, 35 gigawatts. South Korea about 15 gigawatts. And Russia, about five gigawatts. Turning over to the OECD countries, we do see capacity additions for Japan. We see them adding about 20 gigawatts of capacity, but this is much less than the 65 gigawatts of capacity that they had before the plants were shut down after the nuclear disaster in 2011.

Another thing worth noting about the OECD countries is that many countries such as German and Switzerland have national plans to phase our nuclear in favor of renewables. And that's – we're expecting 34 gigawatts of capacity to be taken offline over the projection period in Europe. And you can see that on the graph on the left-hand side at the bottom.

OK, turning to industrial and buildings, focused mainly on the non-OECD. Again, two things worth noting here is that natural gas use increases in non-OECD and still remains a very competitive fuel for use in industrial processes. One of the things that is interesting to note about this graph is coal, which was getting squeezed out in terms of shares and electricity generation, doesn't get squared out nearly as much – it only declined slightly over the period because fuel switching opportunities are rare in the industrial sector. And the amount of new equipment, such as boilers that can use other fuels, is relatively small to the industrial base. So one of the interesting things in this graph is because the opportunities are rare, is that coal stays relatively constant.

Turning to residential and commercial sector energy use, there's basically residential homes, our commercial sector includes retail space. Non-OECD Asia – as you can see looking at the red parts of these two graphs – non-OECD Asia accounts for more than 50 percent of the world increase in residential and commercial energy use as per capita income increases by about 3.7 percent a year for the region as a whole. Despite slower economic growth than in the past, China accounts for 50 – I'm sorry – 46 percent of the increase in residential consumption, and 30 percent of the increase in commercial consumption.

So the next graph shows per capita residential energy consumption across OECD and non-OECD regions. One thing that's worth mentioning is that per capita residential energy consumption remains higher, on average, in OECD countries. There's greater spending on energy-intensive services, such as heating and cooling. But as we go over the projection, per capita residential energy consumption decreases by about 0.1 percent a year. Compare that to non-OECD where per capita residential energy consumption increases by 0.7 percent a year.

One of the things I like pointing out – like pointing out with these sets of graphs, if you look at non-OECD per capita residential energy consumption is greatest for Russia. That's largely due to a great need for space heating. The equivalent on the OECD side is Canada. You notice that they have quite large per capita residential energy consumption. And then going back to non-OECD, you see that the Middle East has high per capita residential energy consumption because of cooling needs.

Turning to transportation, water, gasoline, and diesel continue to dominate the transportation fuel mix. The use of refined petroleum and other fuels as a share of transportation energy delivery decreases from 95 percent to approximately 88 percent. Two other things worth pointing out is in that red bar on the bottom we do see a large increase in jet fuel as demand for air travel increases. This is a story both across OECD and non-OECD regions. And if you look at the top, with electricity and natural gas – which is in green, is a little bit in there – we do see the use of these fuels almost tripling. But again, they're starting at a fairly low base.

Turning to passenger transportation demand, anytime you talk about energy use with transportation demand there are two counteracting forces. The first is increases in demand and more vehicle miles traveled. The second one is energy efficiency. In OECD there are stricter energy requirements. Not only that, growth in transportation demand is expected to be much slower than in non-OECD countries. And with those two counter-opposing forces, it turns out to be the case that the energy efficiency slightly wins out. So we see transportation energy demand increasing by 4 percent in OECD countries.

Turning to non-OECD countries, you see a much different story with those large rates of growth and those large increases in transportation demand. If you look particularly at light duty, which is in blue, you can see that increase that comes with the transportation demand, as the increases in transportation demand need to a lot more vehicle miles travel that totally outstrip the gains that might be made through energy efficiency.

Turning to freight demand, focus again mainly on the non-OECD countries. We see a large increase in marine transport over the period. And what we also see as well is a shifting more towards heavy-duty vehicles as road and infrastructure is developed to support these vehicles. So as these roads develop, more heavy vehicles can travel on the road, it's quicker to get places. So we do see a shift in terms of the types of trucks that are used for freight transport.

So that's the main part of my presentation. I do want to remind people that we will have these issues and focus coming out over the next couple of months, that one of them will focus on transportation and electric vehicles, the other on economic growth rates. Two of them will – or, the other two will focus on investment in oil and gas resources, and how the Paris Climate Agreement factors into our projections. These will come out over the next few months. And if you want to keep informed to know exactly when they're coming out, I'm providing at the bottom of this slide – and I'll leave it up here at least for a while – a link that you can use to get email notifications for when anything

new occurs with the AEO. And if you sign up at this link, you'll be able to receive immediate notification when those reports are ready, so thank you.

MR. VERRASTRO: So, Ian, terrific job. (Applause.) Covering a wide array of energy issues and analyses. Looking out at the audience, I suspect you're going to get a number of questions on transportation and on renewables and the assumptions behind that. So let me take my discussion a bit of a different way. We've got time. If you can roll back to slide 10, just for a second.

MR. MEAD: There we go.

MR. VERRASTRO: I'm sorry. So it's 10 in my notes. That's it, OK.

MR. MEAD: OK.

MR. VERRASTRO: OK, so a lot of people are going to wonder on the assumptions of – and, by the way, so this was embargoed for release until 10:00 this morning. You can find it on the EIA website in its entirety, including the tables, the 2050 numbers, and the analysis that goes with it. But for purposes of this discussion, the high oil price case. So if you take us from 2017 to 2020, how do we get to \$150-plus? Is that a disruption? Is that under investment? What are the assumptions that lie behind that?

MR. MEAD: A lot of it is the tight oil supply, that resources don't play out quite the way that we feel. And then a lot of that is the demand story as well, much greater growth that kind of outstrip. So you have to have – as I said in this case, you have to have generally much tighter supply and larger growth as well, in order to get, you know, something that looks reasonable that's internally consistent, that explains –

MR. VERRASTRO: And can you talk a bit about – so the IEA has – EIA has always been limited by existing law when you put your assumptions together for the reference case. So how difficult is that? You know things are going to have to change, and yet you have to plan and analyze and forecast based on the current set of laws that are in –

MR. MEAD: I'll start out – even though this is a discussion about the International Energy Outlook – I'll start out with what we do in the AEO and then talk about how it's a little bit different with the IEO.

You know, it's – to use the current laws and policies, it does create differences with other forecasts. You know, and generally what you see is a little bit more demand sometimes than other forecasts. Sometimes you see a little bit higher oil prices as well. But we do think it's important to at least look at current laws. You know, we're trying to project what's going to happen with energy markets. And when it does come to policy uncertainty and things like that – and we're policy neutral. We're not a policy shop. We try to address those with side cases that are informative.

MR. VERRASTRO: And I think the side cases are terrific idea, because there's sensitivity analysis more and more as you look out where you need to go. And to give the range of options for policymakers and what the conclusions look like, that's just critically important.

There's a second slide, so flip ahead one or two. Next one. Well, OK, so we can use this for purposes of discussion. But so the notion of liquid fuels. You talked about industrial processes and

process heat is going to be important. There's certain things that you can get from renewables and other things where you need higher heat content. How much does that play into it on the industrial side for conversations? Because when you look on at Btu basis, people can say, well, renewable – we're going to have adequate renewable capacity, but it doesn't fit all these needs and cases.

MR. MEAD: The renewable story is mainly one associated with electricity generation. We do see some switching with natural gas in the industrial sector. It is a competitive fuel. But the renewable story is mainly one associated with electricity generation. So you know, that will play out in a generation and it will play out in the end use and in the residential and the commercial sectors. I had stated something about little opportunity for switching away from coal in some industrial processes. There are some areas where you could do that with electric arc furnaces and things like that. But those opportunities are much more limited, so.

MR. VERRASTRO: And again, on the sensitivity cases, we just ran a workshop here on nuclear. So the notion of – in the United States for example – that we do premature nuclear retirement, the stress that that puts on the system. So renewables fill some of the gap. Efficiency fills some of the gap. Natural gas will fill a lot of the gap. Just on an economic basis, what does that do for, like, natural gas pricing and exports, that kind of stuff? It's a very dynamic system that we've now entered into.

MR. MEAD: Yeah. Yeah. We expect the outlook for natural gas to be good, with increased supply and prices remaining low. And this has been, you know, of course, one of the big stories over the past five or 10 years is just the big boom in natural gas. And we still have – you know, even though our results this year, you know, are toned down a little bit because of growth rates, we still have – do have a very favorable outlook for natural gas, in terms of being able to supply the world's needs and it being a competitive fully priced fuel.

MR. VERRASTRO: Yeah, I'm pleased that you're focusing the liquids because Adam and I and Guy and Sara have been talking a lot about the liquids and the challenge it presents, even for OPEC. There's a lot of other things that are escaping the system, and yet people use them in the final analysis.

One last question, this is more short term. So we just came off Harvey and Irma. And I would say that the government did a great job in terms of the updates that were provided in great detail. As people look forward, and you're responsible for the reliability and accuracy of data, the amount of training that goes on, or the price movements that go on – even in a conventional, fundamentally sameness model for some of this stuff – it's attributable to where you get the data, how you analyze the data, right? So what are you doing at EIA to make those improvements? I know, like, the productivity report on wells was a great step forward. The analysis that you're doing. How do you stay up with the changing environment?

MR. MEAD: I think a lot of it – and one of the things that's really interesting and nice about EIA, you know, before I came to EIA I worked for another statistical, you know, agency, the Bureau of Economic Analysis. And a lot of our data came from survey data. And we were kind of envious of EIA to be able to scrape data off the web, to find alternative sources. And one of the things that's really nice about EIA is that, you know, we do collect our own survey data, you know, for residential and commercial energy consumption. You know, we do collect prices from various private sources. But we're constantly on the lookout, seeing what's out there.

The one difficulty that does pose, and I think one place where there is value for EIA, is a lot of times this data is unstructured, it doesn't have much context to it. So when we do find, you know, sources of data on the internet, we do like to look at it, make sure that it consistently fits in, and we understand exactly what it's measuring – because a lot of times with the data you find on the internet, you know, it needs to be benchmarked to something. It needs to be quality-checked. It needs to be given that structure. But a lot of it is just looking at as much real-time data as we can, you know, developing relationships. You know, a lot of the data we do produce comes from private sources as well. It's not just a government agency collection effort.

MR. VERRASTRO: So, in a public forum, you want to give a cautionary note on weekly data?

MR. MEAD: (Laughs.) I'll let John do that. (Laughter.)

MR. VERRASTRO: John, would you like to make a comment?

Q: The only thing I would add to what Ian said is, you know, as the demand for information changes, OEI is constantly sort of reauthorizing its forms. And we have our analysis shop and our data shop trying to understand what these data means for the policymakers and the country to make decisions. And hopefully, after reauthorized forms, we're always asking for new and different information to help us get what's needed.

MR. VERRASTRO: Yeah, what we really need. Yeah.

Q: In addition, we're searching, you know, the web, as Ian says. A lot of new sources of data are out there. We try and acquire them. We try and work deals to be able to provide whatever we can to the public so they have that information. And that's been very useful for us to our analysis, especially in the near term, short term.

MR. VERRASTRO: Excellent. And I think you're doing an excellent job.

All right, so let me open this session up. We have a couple of quick rules here. Size of the audience, so wait for the microphone, raise your hand, identify yourself and your affiliation and to the extent you can ask your question in the form of a question, we always find that to be helpful. (Laughter.)

So go ahead. I'm going to start in the back of the room.

Q: Hello. Thank you very much. Gabriel Barbadi (ph) from Voice of America.

I wonder what are your expectations for oil production in the Middle East, and specifically Iran, please? Thank you.

MR. VERRASTRO: (Laughs.) Over the next 24 months. No, I'm only kidding.

MR. MEAD: I – what I will say – and, you know, I think it's a little bit more, you know, of a short-term issue, is that we're looking at long-term projections. You know, we do expect more production to come out of that area. I think – I think the issue is, and the difference in the place you'd want to look is in our short-term energy outlook, you know, to get some sense. But, you know, I think some of the concern with what's going on there – you know, for long-term projections we're looking at

the period of 2040. You know what I mean? So this – you know what I mean? A lot of those more short-term things.

You know, we do – as we develop the IEO, we do think about current conditions, you know, try to assess how long they might last. Generally anything that's happened within the past two months won't get into those assumptions, because we do have to close the door. But, you know, a lot of these issues which are more shorter-, mid-term issues, I don't want to say they melt away, they go away, they don't inform our long-term projections. But, you know what I mean, they're less acute of an issue, so.

MR. VERRASTRO: Yeah. Down on the third row. We have two questions right here.

Q: Hi. Thank you. Sam McLeod (sp) at King's College, London.

So my question, if you go to slide 10 please, is about your sort of headline number on total energy consumption. So in last year's IEO, the total energy consumption was 815 quadrillion Btus. This year in the high growth case you're below 800 quadrillion Btus. If it's not GDP, then what are the drivers in that reduction? Is it energy intensity? And if so, then what are the drivers in energy intensity?

MR. MEAD: Our – you know, this comes down to – and I should probably say something about comparing this year's outlook and last year's outlook. And the outlook is generally the same, but the two major differences were lower growth rates and then we do have lower oil prices as well, going into the projection. And what that translates to, I think last year we had 3.4 percent, you know, world growth on average. What that translates to is, if I remember correctly, about 10 percent, you know, higher energy demand with those higher growth rates.

In terms of our outlook, you know, you can proportionally push that 10 percent down to the fuels. We've got a more favorable outlook on renewables. Those – you know, the difference is only about 2 percent lower than the last go-round with the IAO, with nuclear. We're a little bit more pessimistic in the sense that we've got, you know, 20 percent less nuclear, you know, by the end of the projection period.

In terms of the fuel prices, that kind of plays out in the country-level detail with more OPEC projection. We're seeing less GTLs and CTLs because oil prices aren't as high. But that is the main driver of why the results are lower in terms of energy consumption, are those lower rates, despite the fact that, you know, when it came to the details of particular fuels and particular sectors we might have changed a little bit of our outlook of exactly how that played out.

Q: Thank you. My name is Sergio Martinez, and I am coming from the Energy Program at the Inter-American Dialogue.

I wanted to ask you a question about clean transportation and electric vehicles. So, for example, what can developing countries do in terms of policy (demonstrations ?) to foster clean transportation? And especially electric vehicle markets, especially in Latin America, where the share of electric vehicle markets is, like, less than 10 percent of 5 percent, or so.

MR. MEAD: Yeah. That one – that one's difficult to answer. You know, I'm really not, you know, well-equipped to say, you know, this is exactly, you know, how to get increased penetration. What I will say is we've got a more favorable outlook at EV penetration, you know what I mean, and a

lot of research has been done in this field. You know, we will do the side cases looking at different EV penetration rates. You know, there are a lot of factors here. There's the technology factor. There's the demand. There's developing the infrastructure to support it. Some countries, like Finland, have many more electronic vehicles on the road because they've spent a lot of money to develop the infrastructure and to support it. You know, I would kind of turn to those sources and those experiences if you're interested in seeing what might be done to encourage the use of more EVs.

MR. VERRASTRO: OK. And just pass it behind you, Mark Finley.

Q: Thank you very much. Mark Finley with BP.

Ian, just first, thanks to you and your colleagues at EIA for producing yet another excellent piece of work, and a really valuable contribution to the energy discussion. It's very much appreciated and a real resource.

MR. MEAD: Thank you.

Q: You mentioned shale in the context of natural gas, but not oil. And I noticed that your forecast for U.S. oil production, in eyeballing the chart, look like it grew by about 2 million barrels a day in total between now and 2030. You know, that's kind of two years' worth of steel forecasts. So I'd be interested in your forecast for – you know, can you tell me more about the tight oil dimensions of your forecast?

MR. MEAD: We have – and I'm going back to the AEO that we released in January – part of what you saw is a little bit of the artifact of how it was binned. But we do see oil production, you know, from the U.S., being relative flat in later years of the projection period. And part of our explanation with the AEO is that as more of these resources are developed there's diminishing, you know, marginal productivity associated – or the productivity with the newer wells starts decreasing because, you know, in theory, the producers do a pretty good job, it's not a perfect science, of going to the sweet spots first. So that was our story in terms of oil production with the U.S. from the IEO. Basically, even though it declines a little bit and there was a hump, you know, we said it was relatively flat in terms of the long-term outlook.

MR. VERRASTRO: Why don't you pass it that way, and then we'll get that side of the room. Right in front of you.

Q: Thanks. Sreekanth, Northeast Clean Heat and Power Initiative.

This is regarding – you had mentioned the per capita residential demand for energy for India. It's projected to be low, even in 2040. What are the reasons? Is it – is it because of the access to energy? Or is it because of improvements in energy efficiency? Because the government of India is focusing a lot on energy efficiency improvements. But at the same time, energy access is still a – you know, is still an issue that remains to be resolved. So why is the per capita residential demand for energy in India still low in 2040?

MR. MEAD: I'll generally mention something about just what I know, and then I'll turn it over to one of my staff members, to see if they – you know, if they want to add a little bit to it. You know, we're certainly aware of the fact that there are many reforms. And, you know, access to electricity – the electrifying villages is an important aspect. You know, in terms of long-term projections, you

know what I mean, we've got to think about it. We've got to think about, you know, how that's going to occur. I'll have to look more specifically and get back to you, unless anyone can fill in on exactly what's going on in India. But I do know that it was a factor that was taken into consideration. You know, all these reforms that were planned, including the electrification and the delivering of more energy services, you know, to more of the rural parts of India. So, like I said, come up afterwards, I'll give you my business card and I'll hook you up with exactly who can help you out with exactly what we did and what our thinking was on India.

Q: Sure.

Q: Would you like – would you like to say something on that?

MR. MEAD: I kind of left it open. Please jump in. Yeah.

Q: This is just a simple ratio of the energy to –

MR. VERRASTRO: We got a mic right behind you.

Q: (Comes on mic.) This is just a simple ratio of the energy consumption per capita, which is in India – even though it shows lower, but is four times higher than what it was in 2015. And the reason is that consumption in India for residential is growing at 2.4 percent and population is growing at 0.9 percent. So this is just – it's not taking into account any structural changes or weather or efficiency. But relatively to 2014, still is more than four times higher. So it is growing, but not as fast.

MR. VERRASTRO: OK. Other questions? Back to this side. Two rows back. There you go.

Q: Thank you. (Off mic.)

In terms of Middle East energy consumption, is there an expressed assumption in terms of – (off mic) – or is that factored into – (off mic)?

MR. MEAD: It's considered in our outlook. You know, there's the big Saudi – you know, 2030, there's, you know, discussion of some reforms in the Middle East. That is considered, you know, in terms of thinking about economic growth and how we think. You know, that was one of the areas where we did see – expect growth, you know, both economically and in terms of energy consumption going forward. So, you know, anything – with the exception of something that might happen within the past two months, it is kind of factored into our calculation going forward.

Q: (Off mic.)

MR. MEAD: I'm not going to weigh in on – you know what I mean – how well I think they go. But we do see – you know, unless that – at least economically, you know what I mean, an increase in energy consumption in those regions. And, you know what I mean, in terms of the – you know, the potential political – what we do, let me state it this way, is more of a meta-analysis and, you know, thinking about the long-term trends rather than, you know, judge individual – you know what I mean – whether this definitely is going to work or not, so.

MR. VERRASTRO: So going back, you talked about one of the side cases you're going to do, the article's on the Paris Climate Agreement. Treating the INDCs fait accompli, INDC plus going forward, what do you do to match the numbers? What is that analysis going to look like?

MR. MEAD: The three things that make that really difficult is, first of all, the Paris Accords covered much more than just the carbon and energy-related carbon dioxide emissions that are included in our modeling systems. A second complication is that, you know what I mean, sometimes the targets aren't altogether clear or, you know, you're not sure how they're going to get there, and they're grouped in different ways across different countries. And then a third complicating factor is even though, you know, you can map some countries individually one to one, we deal with regions in the WEPP survey.

What I will say – you know, without pointing fingers at any particular country – is that there are some regions where we don't assume that it's a binding constraint – you know what I mean. And part of that is based on history. You know what I mean, we do make some adjustments if their goals have adjusted. But I will say this without pointing fingers, it isn't the case that every single country that has made an agreement necessarily reaches its targets.

MR. VERRASTRO: Well, because we didn't even discuss the interplay on trade agreement and sanctions, what that does to economic growth assumptions globally and how that translates into energy demand and flows, right? And as Lynn (sp) knows, the whole notion of U.S. light oil with refineries configurations, what are being built now, what people are going to use, and then the separate gas stream. I mean, this is getting more complex as we move forward.

Other thoughts here, folks? Thanks.

Q: Thank you. Hi, I'm Joniel Cha at Johns Hopkins University, SAIS.

Given that China is the world's largest car market, and that the U.K., France, and China recently announced that they are going to phase out fossil fuel vehicles and focus on EVs, I was wondering if you could give us a brief appetizer on the upcoming publication on EV penetration. And if you could also give your analyses on EV penetration in the United States, specifically. Thank you.

MR. MEAD: OK, for the first part of the question I'll address, the paper itself is going to look at – with our new international transportation demand model – it's going to look at different EV penetration rates and what effects that has on the energy economy. And those changes are going to mainly be a result of changes in tastes and preferences, as opposed to any policy considerations or any improvements or – you know, in technology. Just the reference case with, OK, people are much more, you know, willing, their tastes and preferences have changed.

This year in the IEO we were much more optimistic about penetration rates. It will come out in the paper that in the last IEO our stock of electric vehicles worldwide was about 4 percent and this year we bumped it up to about 14 percent. So we are a bit more optimistic. In terms of the specific U.S. market, I'll turn it over to John and Melissa. Do you want to say a little more about that?

Q: So in the U.S. market, all this information's available in the AEO, but we're still at a little less than 10 percent of battery electric as well as plug-in hybrid electric. And a lot of that is going to be driven by your ZEV mandates, as well as the CAFE standard. And as far as all the mandates, as Ian was talking with the NRDCs, with not really knowing how they're actually going to do them, not –

they're not – for the mandates, they're not binding laws. And so in the countries or regions that have said that they have those, we definitely see more penetration of electric vehicles – whether it's battery electric or plug-in hybrid. However, we're not assuming that in 2030 India's only going to be selling electric-type vehicles. So we do see more favorable adoption in those countries and regions, but not 100 percent.

MR. VERRASTRO: All right. So a lot to absorb here. And then if you'll give us your email, folks can come back to you – I'm only kidding. (Laughter.) We look forward to the EIA presentation because it's one of the kind of landmark presentations that we use here. We have companies that come in, we have the IAE, we have OPEC now that's doing forecasting. The sameness worries me a little bit, whether or not we're missing stuff. I think the world is changing very quickly. I certainly applaud the work that you're doing on the side cases, because increasingly that's going to be more important I think to help policymakers figure out the short term, and the short term has a big influence on the long term.

But if you'll all join me in thanking Dr. Mead. I think this is a terrific presentation. I hope you actually will download the study, read it, absorb it, and then come back with questions. We're going to continue looking at this – the market issues, the investment gap issues, how we still keep the climate change discussion alive, and what it does to technologies as well, and the role of the Middle East, of course, and liquids. So those are just a couple things – since Adam's been here – we need to add it to our list of things to do.

But join me in thanking Dr. Mead. And please come back again. (Applause.)

(END)