August 3, 2017

MEMORANDUM FOR: Ian Mead
Assistant Administrator for Energy Analysis

FROM: John Staub
Director, Petroleum, Natural Gas, and Biofuels Analysis

Subject: Summary of Oil and Gas Working Group Meeting held on July 26, 2017

This memorandum provides an overview of the presentations given during the first AEO2018 Oil and Gas Working Group meeting and a summary of the resulting discussions that took place. The presentation slides are available in a separate document.

Model updates

The meeting began by mentioning that this will be the first year projections through 2050 would be in included in the AEO annotated slide deck. For the previous AEO, projections through 2050 were only available in EIA's table browser. Many of EIA's modeling priorities were chosen to address the added uncertainty that arises with the extended projection period.

Anticipated changes and modeling developments were then discussed for each of the three modules covering oil and gas markets: the Liquid Fuel Market Module (LFMM), Natural Gas Market Module (NGMM), and Oil and Gas Supply Module (OGSM). The following points were highlighted:

LFMM

- The world oil prices for AEO2018 will be lower than those for AEO2017.
- New pipeline capacities will be added to model, including the Dakota Access.
- Reduced sulfur specification for marine bunker fuel in 2020 will be introduced.
- Biofuel production capacity and feedstock supply curves will be updated.

NGMM

- The NGMM will replace the Natural Gas Transmission and Distribution Model.
- NGMM will add granularity and provide flexibility for bi-directional flows.
- Data on prices, liquefied natural gas (LNG), and information Mexico will be updated or more thoroughly modeled.

OGSM

- Estimated ultimate recovery and technically recoverable resources will be updated.
- Changes will be made to accommodate new NGMM model and better account for trade with Canada.
- Natural gas plant liquid (NGPL) and crude oil API gravity characteristics will be updated.
- The responsiveness of natural gas production to prices will be thoroughly examined.

Discussion

The discussion followed the order in which the oil and gas market modules were presented.

LFMM

The only question related to LFMM that arose was why oil prices were expected lower for AEO2018. EIA staff stated that OPEC production was higher and demand from OECD and non-OECD countries was slightly lower compared to previous AEO assumptions. Thus, EIA lowered the price paths throughout the projection period. In addition, data from the futures market has narrowed the range of uncertainty associated with oil prices, which slightly tightened the difference between oil price paths in the high and low price cases.

NGMM

Many participants were interested in the new module with the first question asked being whether NGMM will have a supply and demand curve representation similar to that used in the related international model. Staff responded that NGMM did not quite have the same type of representation, and options were being considered for future updates. In addition, EIA's work on its Global Hydrocarbon Supply Model (GHySMo) may help inform such a development for NGMM.

A participant asked how many regions (hubs) would be represented in the module. EIA stated a node currently exists for each of the lower 48 states, plus 2 in Canada and 5 in Mexico. In addition, nodes currently exist for all border crossings and at each coastal state for liquefied natural gas (LNG).

A question was raised regarding the switching the Citygate pricing methodology between the two models. EIA staff indicated that with the previous methodology the overhead cost of maintaining revenue calculations was significant and the model was unable to accommodate more flexible rates. It was also difficult to assess accuracy of results relative to published rates, and one had to deal at times with a misalignment with the actual city gate prices. In the new model, EIA sets state city gate prices using estimated equations where Citygate prices are a function of state spot prices and an associated quantity. The main advantage of the new approach is that it is a straightforward and expected to give reasonable results with a few notable exceptions when spikes in spot prices occur.

A few questions were asked that related to the build out and directionality of pipelines. EIA staff explained that the new model decides on the direction of flow based on variable tariff curves and solves for flows between hubs. Some pipelines have zero capacity for bi-directionality. And the capacity between two given points is not necessarily 100% reversible, especially in the short-term. However, the direction of the flow for many pipelines can change based on relative prices and seasonal trends. Staff also indicated that the new model takes into consideration which pipelines have a demonstrable ability to change the direction of flow.

One participant specifically asked why are West Texas and East Texas nodes missing, especially as the Permian increases production. EIA staff explained that Texas is really three or more regions with intrastate constraints. However, it is difficult to ascribe state demand to sub-state regions with the data EIA collects. Thus, the demand models in NEMS do not provide this sub-state detail. The overarching goal of NEMS for the AEO is to build long-term market equilibrium representations, so sub-state detail is

less of a problem than other issues. Staff concluded by stating that they were aware of the issue, particularly for Texas and California. Staff also mentioned that it is relatively easy to build pipelines and infrastructure within Texas, which helps the Texas market function efficiently.

A question was also asked about how EIA estimates monthly demand at state levels. Staff responded that historical EIA data by state is used in addition to data from other NEMS models. A possible consideration for future improvement of this estimation would be to include growth rates and population changes.

Two final questions were asked about liquefied natural gas supply: Do the results for the world supply and demand of LNG come from the IEO and get fed into the NGMM? For NGMM, is there a high technology case that considers demand-side technology (e.g. higher power generation, reductions in battery cost)? Staff responded by stating that part of EIA's calculation takes into account the IEO's result for world supply. In addition, electricity generation is done by Jim Diefenderfer's group, and they will have their own working group soon.

OGSM

EIA presented initial analysis of estimated ultimate recovery (EUR) of tight oil wells drilled in 2016 and 2017 in the Permian basin, and Marcellus and Utica shale gas wells drilled between 2012-2016. EIA staff indicated that they were also looking for assessments of the resources in the Delaware basin of the Permian. Analysis of the most recent EUR data adds about 300 TCF of natural gas resources, mostly in the Marcellus and Utica plays, and are consistent with the recently release Potential Gas Committee report. Further, EIA staff indicated they are in the process of updating natural gas plant liquid and crude oil API gravity characteristics and examining natural gas supply response to prices, but the work was not far enough along to show drafts.

One participant asked if the plays include stacked wells. EIA staff indicated that stacked formations within plays were included—for example, five layers will be included in the Permian Wolfcamp for AEO2018. In AEO2017, only three layers were included. Wolfcamp is the biggest change for unproved total recoverable resources. The resources are divided by county. EIA would like to identify which zone was being targeted in the historical well data to better reflect the EUR in each layer.

A question arose regarding whether 100-acre spacing is too large for the surface area of a horizontal well. EIA staff explained that each stacked formation is assumed to have 100-acre spacing, but the surface spacing is much closer. The model also allows wells to be drilled closer than 100-acre spacing for each layer but with diminishing returns on EUR as they interfere with other wells. However, more wells with lower EUR could potentially produce more overall.

Two additional but unrelated questions were asked: Can we break out Alaska in the resource chart? And is there a correlation between drilling cost and oil price? Staff responded by stating that EIA does break out Alaska and regions in tables 9.1 and 9.2 in the AEO Assumptions Report. In addition, there are adjustments in cost related to historical oil price and level of drilling. As the oil price rises, drilling activity increases which leads to increases in drilling costs.

One participant observed that the Permian has fairly constant natural gas production compared to growth in oil production. They followed up by asking whether we are getting "drier" oil from the Permian. EIA staff indicated that scaling makes the Permian look small on the graph. The growth in

natural gas production in the Marcellus far exceeds the growth in other plays, so the Permian appears to be fairly constant on the graph. However, Permian natural gas production has increased over 22% from the level seen in June 2016, similar to the growth of 26% in crude oil production.

One participant was particularly interested in knowing the amounts remaining and already produced from technically recoverable reserves. EIA staff provided context by stating that there have been 363 trillion cubic feet (Tcf) of dry natural gas produced from 2000 through 2016 in all of the United States (not including natural gas plant liquids). However, the chart in the presentation does not show cumulative production. The chart also does not include additional resources that will become technically recoverable as technology further advances.

This discussion on technically recoverable reserves concluded by noting that the presented chart likely underestimates the amount remaining. Drillers will target higher quality resources, then move into lower EURs, as production costs come down with technology. The supply model feeds the market as demand is placed against those resources. NEMS is currently running to 2050, so we're not getting to the end of these resources, but as we go out further the question becomes how technological changes will affect the EUR and cost of production.

A final question related to whether there a gas supply curve passed between OGSM and NGMM? Staff informed participants that OGSM determines expected production at a price passed from the NGMM. The expected production and a short-term supply elasticity is sent to NGMM, which balances supply and demand, sends back how much is needed and at what price.

Assumptions for announced discoveries in the Gulf of Mexico were presented, but no questions were asked.

Additional issues

There were some more general questions:

- What are EIA assumptions for the high/low technology cases? EIA staff indicated that the current plan is to use the same assumptions as AEO2017.
- Is there a high technology case that considers demand-side technology (*e.g*., higher power generation, reductions in battery cost)? EIA staff indicated that the team running the Electricity Market Module would be best group to talk with.
- Will the slides be posted? EIA staff informed participants that the slides would be posted. They also noted that they could contact the AEO team with feedback and questions. In addition, the next working group meeting with preliminary Reference case results will be held in September.

Attendees

Guests (in person)

John Powell	DOE

Registered Guests (WebEx/phone)

Geoffery Brand	API
David Shin	API

Celeste M. Marshall	API
Radford Schantz	BOEM
Sarah Coffman	BOEM
Ben Schlesinger	BSA Energy
Beth Lau	Canadian Association of Petroleum Producers
Mark Pinney	Canadian Association of Petroleum Producers
Stuart Mueller	Canadian Association of Petroleum Producers
Deborah Gordon	Carnegie Endowment for International Peace
David Austin	Congressional Budget Office
Ron Gecan	Congressional Budget Office
Shree Vikas	ConocoPhillips
Sarah Ladislaw	CSIS
Jairam Gopal	Deloitte
Bill Noel	Deloitte
Kathleen O'Dell	Deloitte
Ryan Daly	Deloitte
Donald Hanson	DOE
Seth Snyder	DOE
Yen Zhou	DOE
Jennifer Li	DOE
Amy Sweeney	DOE
John Anderson	DOE
John Powell	DOE
Douglas Hollett	DOE
Kevin P. Quinlan	DOE
Isabella E. Ruble	DOE
Hannah Gagarin	DOE
Alan Yu	DOE
Fred Joseck	DOE
Elena Thomas-Kerr	DOE
Brian D. Lavoie	DOE
Kenneth Vincent	DOE
Nancy Johnson	DOE
Jamie Kern	DOE
Elena Melchert	DOE
Aaron Mintzes	Earthworks
Jeffery Eppink	Enegis
Anthony Petruzzo	Energy Ventures Analysis
Ozge Kaplan	EPA
Carol Lenox	EPA
Elizabeth Miller	EPA
Brian Keaveny	EPA
Maria M. Coronado	EPA

Paul Argyropoulos	EPA
William Yelverton	EPA
Robert E. Gardner	ExxonMobil
Yufen Shao	ExxonMobil
Nicolas Sawaya	ExxonMobil
Fu Dong	ExxonMobil
Irene C. Chang	ExxonMobil
Benjamin Salisbury	FBR
Ramses Cabrales	FERC
Ken Ditzel	FTI Consulting
Marilyn Brown	Georgia Tech
James Kliesch	Honda
Kevin Birn	IHS Markit
Stephen Beck	IHS Markit
Caldwell Bailey	IHS Markit
Barbara Treat	InfrastructureWorld, LLC
Marshall Carolus	INTEK Inc.
Yelena Dandurova	Leidos
Lee M. Van Atta	Leidos
Adrian Shaner	Leidos
Ken Walsh	Leidos
Fred H. Hutchison	LNG Allies
J. Alan Weber	MARC-IV
Tom Curry	MJ Bradley & Associates
Keith King	Moyes and Co.
Richard Nehring	Nehring Associates
Nadejda M. Victor	NETL
Charles A. Zelek	NETL
Donald J. Remson	NETL
Maria C. Vargas	NETL
Joel R. Theis	NETL
Peter C. Balash	NETL
Gavin C. Pickenpaugh	NETL
Thomas J. Tarka	NETL
Emily Newes	NREL
Niko Kydes	OnLocation
Asher Miller	Post Carbon Institute
Shashank Mohan	Rhodium Group
Amir Zaman	Rystad Energy
Robert L. Kleinberg	Schlumberger
Henry Nuzum	SEACOR Marine
Michael Lynch	Strategic Energy & Economic Research Inc.
Gurcan Gulen	The University of Texas at Austin

Svetlana Ikonnikova	The University of Texas at Austin
John Browning	The University of Texas at Austin
Robert Dohner	U.S. Department of the Treasury
Ana Cummings	UNICA
Tim Carr	West Virginia University
Paul B. Sankey	Wolfe Research

EIA attendees (in person)

Joseph Benneche
Samantha Calkins
Meg Coleman
John Conti
Katie Dyl (presenter)
Arup Mallik
Elizabeth May
Danya Murali
James Preciado (presenter)
Corrina Ricker
John Staub (presenter)
Terry Yen

EIA attendees (WebEx/phone)

Neil Agarwal
Dana Van Wagener (presenter)
Troy Cook
Laura Singer
David Manowitz
Faouzi Aloulou