Independent Statistics and Analysis
U.S. Energy Information Administration

December 30, 2024

MEMORANDUM FOR: Angelina LaRose
Assistant Administrator for Energy Analysis

FROM: Jim Diefenderfer
Director, Office of Long-Term Energy Modeling

SUBJECT: Summary of *Annual Energy Outlook 2025* (AEO2025) Working Group for Electricity, Coal, Renewables, and Nuclear held on November 12, 2024

This memorandum summarizes the presentation given during the *Annual Energy Outlook 2025* (AEO2025) Electricity, Coal, Renewables, and Nuclear Third Working Group meeting and the resulting discussions that took place.

The presentation materials for these updates, as well as those for past working groups and those focused on other model development efforts, are available separately on EIA.gov.

Overview

Because we did not publish an *Annual Energy* Outlook in 2024, AEO2025 will include an increased number of model enhancements compared with previous years. Developments for AEO2025 include introducing hydrogen representation; improving carbon capture, transportation, and sequestration modeling; improving electric power sector modeling; improving technology representation; and more comprehensively addressing existing and upcoming laws and regulations. This working group focused only on efforts related to improving electric power sector modeling.

Model updates

To begin the meeting, we outlined the model updates and enhancements planned and completed for AEO2025 related to the electric power sector.

Legislation and regulation

- Inclusion of energy communities for zero-emission capacity additions (part of the Inflation Reduction Act [IRA])
- The Environmental Protection Agency's (EPA) Clean Air Act Section 111 (Section 111) for greenhouse gas emissions regulation as finalized in May 2024
- Clean Energy Standards update, with an additional 12.4 gigawatts (GW) of mandated battery storage capacity and 21.5 GW of offshore wind capacity through 2050

Data updates and model developments

- Updated capital cost and performance characteristics for electric power generating technologies

- Updated carbon capture and sequestration (CCS) retrofit costs for coal and natural gas combined-cycle power plants and conversion costs for coal-to-gas power plants
- Reassessed wind and solar resource supply curves
- Updated end-use load shapes using the National Renewable Energy Laboratory's 2018 ResStock and ComStock analysis tools
- Inclusion of new load shapes for, and accounting of, consumption for electric vehicles (EVs) at the point of charging
- Restructured or reduced coal supply regions
- Addition of biomass energy with carbon capture and sequestration (BECCS) technology to capacity expansion technology options
- Inclusion of Palisades Nuclear Plant restart
- Endogenous phase-out of IRA tax credits when CO_2 emissions reduced to 25% of the 2022 level
- Interactions with the new Hydrogen Market Module (HMM) and Carbon Capture Allocation, Transportation, and Sequestration (CCATS) Module

We then presented the general preliminary results for the AEO2025 Reference case.

Summary of preliminary results

- Shares of renewables in the generation mix are above 60% in 2050, slightly higher than in AEO2023
    - Increased projection of wind capacity expansion with updated wind resource curves
    - Higher natural gas price projection than in AEO2023
- Implementation of Section 111 results in almost all coal power plants retiring by 2033
    - Some, but very minimal, coal plants retrofitted with CCS
    - Few natural gas combined-cycle units with CCS come online as well
- Higher overall power demand compared with AEO2023
- Average all-sector electricity prices expected to be similar to AEO2023 as the impact of higher natural gas prices is offset by higher generation from renewables in the mix

We reminded participants that the results are still preliminary and that we plan to release the final AEO2025 in spring of 2025 but no date has been finalized. Notably, additional model developments in other modules to be made after this working group meeting, in particular to the Transportation Demand Module, could have sizeable impacts on the results presented.

After presenting the slides, the meeting then opened for questions and comments regarding the material shown.

Discussion

One attendee asked what is preventing EIA from projecting more growth in renewables? We responded that we are only modeling current laws and policies in the AEO2025 Reference case, which are not enough for complete decarbonization, and that we do not model aspirational goals or pledges.

We received a couple questions regarding demand growth from data centers, including growth due to increasing use of artificial intelligence. We responded that we have updated the commercial module to

reflect growth and that more information would be provided at the upcoming Working Group for Residential and Commercial buildings (held on November 13, 2024).

Another participant asked what the main driver for the increased projection in wind generation was. We responded that the addition of the IRA energy communities provision, in addition to higher quality wind resources being developed earlier in the projection, led to the new results.

An attendee asked about the differing trends in energy storage in AEO2025 compared with AEO2023. We explained that the total amount of standalone energy storage remained about the same, with noticeably less solar plus battery hybrid energy storage in the new projection. This decrease was due to the new update for electric power generating technologies, which showed higher costs for solar hybrid facilities and lower cost for other technologies compared with what was previously assumed. We also mentioned that AEO2025 for the first time includes the option for seasonal storage of electricity through hydrogen technologies (that is, electrolyzers, and hydrogen turbines); however, seasonal storage of electricity has not yet shown to be economic in the Reference case.

Another attendee asked why the power sector CO_2 emissions increase toward the end of the projection period. We responded that the IRA tax credits phase out, leading to an increase in cost for renewables. One participant asked if limited CCS additions were driven by any additional factors like proximity to enhanced oil recovery wells for carbon storage. We responded that the new CCATS model assesses industrial supplies of CO_2 as well as power plants and then optimizes for the lowest system cost including eligible tax credits. An attendee also asked about buffer years regarding the phase-out of IRA tax credits if CO_2 emissions are reduced to 25% of 2022 levels. We responded that the model phases out the tax credits as specified by law with a grace period, so the phase-out is delayed in that sense.

One participant asked if there are any preliminary results in which coal will end up in a scenario where EPA Section 111 does not take effect. We replied that we are still considering which additional side cases to include for AEO2025 and that we are considering publishing a “No 111” case to compare before and after, as people have expressed interest in this. We also received a couple questions from attendees regarding our short-term outlook for coal and natural gas. We suggested these attendees refer to EIA’s *Short-Term Energy Outlook* (STEO) publication.

One attendee asked if AEO2025 assumes the Three Mile Island nuclear facility will restart along with the Palisades Plant. We replied that we do not at this time, because it’s not as far along in working with the Nuclear Regulatory Commission to get license, but that we are keeping an eye on it. We also replied to questions clarifying we do include demand from freight truck EVs in the commercial sector and that we do not include projections for generation from marine energy technologies because those technologies are not mature technologies (not enough information about availability, costs, performance characteristics, etc.). One attendee also asked if we made adjustments to reflect advancements in geothermal technologies. We replied that we plan to update our geothermal supply curve for AEO2026.

Attendees were interested in how the new HMM model works alongside the Electricity Market Model (EMM) to properly apply IRA tax credits, such as the Section 45V subsidy. A participant more specifically asked how clean electricity is accounted for, and what data are passed between the two modules. We

replied that we did our best to represent the Energy Attribute Certificate (EAC) detailed in the 45V subsidy, but only limited information is available at this time due to its novelty. EMM does pass the amount of clean electricity available by region, hour, and capacity vintage to HMM. It also passes hourly electricity pricing to HMM, along with hydrogen fuel demand by season. HMM in return passes hourly electrolyzer load and hydrogen fuel pricing by season to EMM.

Attendees

We hosted the working group meeting entirely online, and 102 people attended, including EIA staff and external participants. A full list of attendees is provided below:

External participants

First Name	Last Name	Organization
David	Shin	American Petroleum Institute
Othon	Monteiro	Advanced Research Projects Agency-Energy (ARPA-E)
Joanna	Cornell	Boston Consulting Group (BCG)
Tosin	Adeosun	BCG
Mark	Jensen	Bureau of Ocean Energy Management (BOEM)
David	Adler	Congressional Budget Office (CBO)
Robin	Lynch	Chevron
John	Martini	Chevron
Kiran	Mishra-Jha	Chevron
Grier	Martin	Chord Energy Corporation
James	Joosten	Connect-USA LLC
Swara	Salih	U.S. Department of Energy (DOE)
Glenda	Oskar	DOE
Andrew	Foss	DOE
David	Wang	DOE
Rachel	Reolfi	DOE
Jun	Shepard	DOE
Derek	Gaston	DOE
Bill	McShane	DOE
Pavan	Ravulaparthy	DOE
Emilie	Lozier	DOE
Jason	Frost	DOE
Greg	Cooney	DOE
Jose	Benitez	DOE
Steve	Frauenheim	Edison Electric Institute
Phillip	Graeter	Energy Ventures Analysis, Inc.
Aqeel	Adenwala	Energy Ventures Analysis, Inc.
Christian	Fellner	U.S. Environmental Protection Agency (EPA)
Stacey	Zintgraff	EPA
Angela	Ortega	EPA
Sarah	Benish	EPA

Chris	Werner	EPA
Melanie	King	EPA
Daniel	Parker	EPA
Nick	Hutson	EPA
Misha	Adamantiades	EPA
Gregory	Honda	EPA
Eric	Marsico	EPA
Serpil	Kayin	EPA
Romey	James	Electric Power Research Institute (EPRI)
Aranya	Venkatesh	EPRI
Anahi	Molar Cruz	EPRI
Silas	Swanson	EPRI
Nick	PIlot	EPRI
John	Bistline	EPRI
Karen	Tapia-Ahumada	EPRI
Rachel	Moglen	EPRI
Garrett	Doty	EPRI
Ken	Ditzel	FTI Consulting
Charles	Azih	Gas Supply Consulting
Matthew	Ives	GTI Energy
Shilpa	Kokate	Hitachi Energy
Boddu	Venkatesh	ICF
Svitlana	Nesterova	Kayrros
Mohit	Mehta	KBR, Inc.
Ryan	Wiser	LBNL
Ken	Walsh	Leidos
Indra	Bhattacharya	National Energy Technology Laboratory (NETL)
Leslie	Coleman	National Mining Association
Amanda	Levin	Natural Resources Defense Council (NRDC)
Wesley	Cole	National Renewable Energy Laboratory (NREL)
Trieu	Mai	NREL
Julianne	McCallum	Nuclear Energy Institute
Amogh	Prabhu	Onlocation
HAO	Deng	Onlocation
Pete	Whitman	Onlocation
Sharon	Showalter	Onlocation
Frances	Wood	Onlocation
Thomas	Sterle	Onlocation
Mojgan	hedayati	PJM
Emmanuele	Bobbio	PJM
Thomas	Heibel	PNNL
Anna	van Brummen	Rhodium Group
Hannah	Kolus	Rhodium Group
Ben	King	Rhodium Group

Candise	Henry	RTI International
Peter	Kobos	Sandia National Laboratories
Joshua	Junge	Sargent & Lundy
Kevin	Lucas	Solar Energy Industries Association (SEIA)
Tyler	Thompson	SEIA
Josh	Norton	Southwest Power Pool (SPP)
Francesco	Memoli	Tenova Inc.
Joe	Perez	The Ohio Consumers Counsel
Sandra	Sattler	Union of Concerned Scientists
Charles	Rong	U.S. Army Research Laboratory
Patrick	Caton	U.S. Naval Academy
Alejandro	Espejo	Wartsila

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