Annual Energy Outlook 2025 Working Group Meeting—Electricity, Renewables, Coal, and Nuclear

EIA Electricity, Coal, and Renewables Long-Term Modeling Team
October 25, 2023

Commenting method

- Comments and questions in chat/Q&A

- Email comments, input, or questions to eiainfoelectricoutlooks@eia.gov

Meeting overview

- Overview of NEMS enhancements for *Annual Energy Outlook 2025*
- Electric power sector enhancements
  - Data updates
  - New features
  - Model performance
- Other modeling activities
- Questions and discussion

AEO2025: Enhancing long-term modeling capabilities

- The energy market is rapidly evolving, with new policies and regulations, new macroeconomic trends, and revolutionary technology change.

- The time pressures of an annual publication cycle work against the necessary enhancements to our modeling system (National Energy Modeling System, or NEMS).

- We are not publishing AEO2024 to devote more development time to:
  - Introducing hydrogen representation
  - Improving carbon capture, transportation, and sequestration modeling
  - ***Improving electric power sector modeling***
  - Improving technology representation
  - More comprehensively addressing existing and upcoming laws and regulations

Improve electric power sector modeling in NEMS

- Goal: Have a model capable of representing a credible zero-carbon emissions electric power sector through one or more likely policy mechanisms
  - Develop or enhance model structures:
    - Seasonal energy storage
    - Bioenergy with CCS (BECCS)
    - Intermittency impacts
    - Electricity pricing
  - More fully represent policies including:
    - IRA provisions (advanced manufacturing, energy communities, credit phase-out)
    - New and proposed EPA regulations (good neighbor rule, 111, mercury rule)
  - Improve model performance
  - Update resource supply curves for hydro, geothermal, biomass, wind, and solar

Focus on activities targeted at enhancing EMM and related modules for AEO2025 release

- EIA and the Electricity, Coal, and Renewables Modeling Team are also involved in a parallel effort to explore and design a next generation of long-term energy models (Next Gen).

- Next Gen efforts are still in an early exploratory and experimental phase and are not expected to be fully developed in time for AEO2025 analysis and publication schedules (with deadlines approximately 12 months from now).

- The Next-Generation Modeling Initiative will explore changes to the code implementation and mathematical representation of our models. Please stay tuned for more engagement opportunities for the Next-Generation Modeling Initiative.

Data and model updates

Data and model updates

- Overnight capital and operation and maintenance costs
  - Includes technologies with significant historical and recent additions (combined cycle, wind, solar), as well as technologies with few installations (nuclear, carbon capture and storage)*
  - In-progress; expect release this winter

- Resource supply curves for wind, hydropower, geothermal, and solar
  - Wind and solar: recently updated in 2019 to reflect new regionality, but we are substantively reassessing available land and resources.
  - Hydropower: updated in 2019 to reflect the DOE's non-power dams study, but we need to capture additional options for hydropower expansions and additions.
  - Geothermal: updated in 2011 to capture *near field* EGS, but we are evaluating a broader representation of EGS that will include a possible change in modeling methodology.

**Previous discussion on the updated overnight capital costs for AEO2025 was held in September.*

Data and model updates

- Electricity finance and pricing
  - Reexamining pricing algorithm under deep-decarbonization scenario for both the wholesale and retail levels (for example, zero marginal cost)
  - Updating regulated utility pricing used in retail price formation in the electric power sector
- Regional intermittent renewable generation
  - Deep-decarbonization scenario *could* require up to 100% solar and wind generation at regional level
  - Currently representing up to 70%; significant uncertainties in increasing this constraint
    - Seasonal storage
    - System reliability/energy supply on an extreme hour basis (spinning reserves and intermittent capacity credits)

Data and model updates

- Load profiles
  - System load profiles: capturing changes to the traditional day/night peak/trough patterns
  - End-use load profiles: representing price/demand feedback driven by EV penetration from different end-use sectors

- Re-regionalization of coal regions
  - Evaluating a representation of three to eight regions, from 14 currently, to reflect decline in the number of coal mines/types to help improve model solve time
    - Continue coal imports given different uses, moisture, and crushing properties associated with bituminous, sub bituminous, lignite, and metallurgical coals
    - Eliminated coal sulfur grades; no longer critical to match coal grade with plant pollution control equipment because most plants have SCRs to control mercury

New features

Inflation Reduction Act provisions

- AEO2023 included largely exogenous representations of domestic content and prevailing wage credit multipliers.
  - We will continue to evaluate any new information, as well as assess the feasibility of endogenous representation.
- Advanced manufacturing production credit (45X)
  - Evaluating DOE and market activity, as well as possible approaches for inclusion in the model
  - Evaluating likely pathways for domestic content qualification and 45X impacts
- Energy communities bonus credit
  - Evaluating approach to represent *supply curves* of energy communities
- Sec 45V credit for hydrogen is in development along with the Hydrogen Market Module.
- Internal Revenue Service has stated all guidance should be out by the end of the year.

New and proposed EPA regulations

- EPA has issued a final update to the *Good Neighbor* policy (part of the Cross-State Air Pollution Rule), which will be included as part of *current laws and policies* in AEO2025.

- EIA will monitor and evaluate how to include the proposed update to the Mercury Air Toxics Standard,

- Proposed Sec. 111 rule to address carbon emissions is potentially far-reaching in its impact and model changes are needed to represent it.
  - More extensive hydrogen utilization than envisioned
  - Relatively complex evaluation needed for trade-offs among hydrogen, CCS, and retirement options
  - Subject to change

Bioenergy with carbon capture and sequestration (BECCS)

- BECCS is often cited as one of the few negative contributors to carbon emissions.

- EIA has long represented both dedicated biomass-to-power as well as co-firing in coal plants.

- We plan on retaining dedicated biomass-to-power and adding an additional dedicated biopower technology with CCS technology.
  - We have not yet determined if we will keep representing biomass co-firing.

Electric Power Hydrogen for Reliability and Trans-Seasonal Storage (EPHRTS)

- Three-year effort to provide a limited representation of hydrogen in the electric power sector
  - Original goal was to allow for a technology that could provide seasonal storage and reliability services in a deeply-decarbonized electric power sector when NGCTs would no longer be available as a generating option.
  - Hydrogen production is just from electrolysis (with ability to track hourly emissions profile of H_2 production); hydrogen is consumed in modified combustion turbines.
  - IRA Sec. 45V and EPA Sec. 111 policies have reinforced the need and urgency for hydrogen representation in the electric power sector but have substantially modified key design characteristics.

- EIA has begun development of a cross-sector Hydrogen Market Module (HMM) to allow for hydrogen production from multiple sources and consumption in transportation and industrial sectors (along with the electric power sector).
  - HMM will adopt key features of EPHRTS to allow for hourly production from electrolysis, retaining seasonal storage representation, and the assurance of flexibility to represent future Sec. 45V guidance.
  - While HMM is under development, EIA will use EPHRTS to evaluate progress toward achieving the goal of representing a zero-carbon electric power sector.
  - We will continue to incorporate the ability to use H_2 in the power sector in base load capacity, per Sec. 111 proposal.

Model performance

Modernize EMM optimization platform

- Current mathematical programing framework for the Electricity Capacity Planning (ECP) and Electricity Fuel Dispatch (EFD) submodules is based on FORTRAN and obsolete OML platform.

- EIA has been undertaking a multiyear effort to convert these to modern AIMMS platform to allow ease of new policies and market structures implementation, as well as improve ease of use for EIA stakeholders.
  - EFD conversion is complete and ready to be incorporated into the main NEMS code set.
  - ECP conversion is scheduled for completion this winter.

- Trade off is slower solve times; current work is to reduce solve times.

Reduce EMM model solve times through parallelization

- ECP model currently accounts for the largest interval of NEMS execution time.

- New features needed to model deep decarbonization will likely require much larger solution spaces and challenge model convergence (which further degrades overall execution time).

- EIA is experimenting with dividing the electric power sector into three models (reflecting Western, Eastern, and Texas interconnections) to allow for a parallel solution.
  - Early tests look promising, but hurdles remain.
  - Trade-offs could include reduced ability to model cross-interconnect trade expansion and other national-level processes such as construction bottlenecks and emission credit trading.

Improve model convergence

- NEMS (and EMM) represent a complex linkage of about a dozen modules and sub-modules representing different energy sectors and decision points.

- Modules are solved iteratively, passing results back and forth until a minimum tolerance threshold is reached for changes from cycle to cycle.
  - When this threshold is reached, the model is said to be converged and assumed to be producing a robust and replicable solution.
  - Achieving convergence with such a complex web of models has proved to be very challenging over the years.

- EMM itself has three separate linear programs and several other sub modules that do not always converge.

- EIA has identified and is implementing model changes to improve EMM convergence.
  - Changes help but do not completely resolve problems with EMM or NEMS in general.

Other areas of the model (non-electric power sector)

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For more information

U.S. Energy Information Administration homepage | www.eia.gov

Annual Energy Outlook | www.eia.gov/aeo

Capital Cost Study | https://www.eia.gov/analysis/studies/powerplants/capitalcost/

Short-Term Energy Outlook | www.eia.gov/steo

International Energy Outlook | www.eia.gov/ieo

Monthly Energy Review | www.eia.gov/mer

Today in Energy | www.eia.gov/todayinenergy

State Energy Profiles | www.eia.gov/state

Coal Data Browser | www.eia.gov/coal/data/browser

Questions

Statement on the *Annual Energy Outlook* and EIA's plan to enhance long-term modeling capabilities

At the U.S. Energy Information Administration (EIA), a core aspect of our mission is to develop long-term projections of the U.S. energy system that inform decision makers at all levels. This work requires keeping pace with rapidly evolving energy markets, policies and regulations, macroeconomic trends, technology innovation, and resource availability.

EIA's National Energy Modeling System (NEMS), which we use to produce our *Annual Energy Outlook* (AEO), requires substantial updates to better model hydrogen, carbon capture, and other emerging technologies.

Our usual AEO publication schedule does not accommodate these necessary model enhancements, which require significant time and resources. As a result, EIA will not publish an AEO in 2024. This decision does not affect publications relying on our near-term modeling, such as the *Short-Term Energy Outlook*.

By retooling NEMS in 2024, the next AEO in 2025 will more comprehensively address existing laws and regulations in the Reference case, including up-to-date provisions in the Inflation Reduction Act and regulatory actions that could be finalized in the coming months.

We have also embarked on a longer-term effort to develop a flexible, next generation modeling framework that is better suited to address the ongoing changes in the U.S. energy sector.

We will continue to communicate with our stakeholders on these critical modeling issues and provide regular progress reports on our website.

Our plan ensures that the AEO will continue to provide a sound and independent long-term perspective on the U.S. energy sector for lawmakers, energy modelers, and other stakeholders.