Annual Energy Outlook 2025 Model Enhancements for the Power Sector

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Meeting overview

- Overview of NEMS enhancements for *Annual Energy Outlook 2025*

- 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 power sector modeling***

  – Improving technology representation

  – More comprehensively addressing existing and upcoming laws and regulations

Improve Power Sector Modeling in NEMS

- Goal: Have a model capable of representing a credible zero-carbon emissions power sector through one or more likely policy mechanisms

    - Develop or enhance model structures for

        - 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 here is 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 bear fruit 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 substantively reassessing available land and resources

  - Hydropower: updated in 2019 to reflect the DOE's non-power dams study, but need to capture additional options for hydropower expansion/addition

  - Geothermal: updated in 2011 to capture "near field" EGS, but evaluating a broader representation of EGS that will include possible change in modeling methodology

Previous discussion on the updated overnight capital costs for AEO2025 was held in September, slides from the discussion are available.

Data and model updates (cont'd)

- Electricity Finance and Pricing

  - Reexamining pricing algorithm under deep-decarbonization scenario for both the wholesale and retail levels (e.g., zero marginal cost)

  - Updating regulated utility pricing used in retail price formation in the 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 (cont'd)

- 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 3 to 8 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 as 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 an energy communities "supply curve"

- 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 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), will be included as part of "current laws and policies" in AEO2025

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

- 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

  – Rule is subject to change

Chrs Namovicz and John Taber, November 2 2023

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

  - Fate of biomass co-firing representation has not yet been determined

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

- Three-year effort to provide a limited representation of hydrogen in the 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 H2 production); hydrogen is consumed in modified combustion turbines

  - IRA Sec. 45V and EPA Sec. 111 policies have reinforced the need and urgency for a power-sector hydrogen representation, 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 power)

  - HMM will adopt key features of EPHRTS to allow for hourly production from electrolysis, retaining seasonal storage representation and ensuring flexibility to represent future Sec. 45V guidance

  - While HMM is under development, EIA will use EPHRTS to evaluate progress toward achieving goal of representing a zero-carbon power sector

  - We will continue to incorporate ability to use H2 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 are based on FORTRAN and obsolete OML platform

- EIA has been undertaking a multi-year 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 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 which don't 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-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