Independent Statistics and Analysis
U.S. Energy Information Administration

June 11, 2024

MEMORANDUM FOR: Angelina LaRose
Assistant Administrator for Energy Analysis

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

SUBJECT: Summary of AEO2025 Buildings Working Group held on May 8, 2024

This memorandum provides an overview of the first *Annual Energy Outlook 2025* (AEO2025) Buildings Working Group presentation and summarizes the discussion the major modeling and data updates planned for AEO2025. The presentation for this meeting is available in a separate document.

AEO2024 pause and AEO2025 enhancements

First, we reiterated that we are not publishing model results for AEO2024. We are using this pause to improve National Energy Modeling System (NEMS) technology and policy representation for AEO2025 and beyond. We have been using NEMS for 30 years, and it has undergone many upgrades and improvements. For AEO2025, we plan to add hydrogen representation and update carbon capture modeling, electric power sector modeling, and technology representation. In addition, we will address current laws and regulations. Within the buildings sector, specifically, we updated several reports and incorporated new data sources, which will help us stay up to date with current technology trends, and we are working hard to address new laws and regulations. We encourage stakeholders to participate in other upcoming AEO working group meetings, where we will discuss other changes to NEMS more thoroughly.

Technology representation

In terms of technology updates, some of the most involved projects include incorporating contractor task reports related to cost and performance characteristics of the technologies we model. During this AEO cycle, we will also incorporate updates to major end-use equipment characteristics (which covers space heating, cooling, water heating, and residential appliances) and distributed generation and combined-heat-and-power technologies, such as behind-the-meter solar and small wind.

The *Distributed Generation Report* characterizes behind-the-meter battery energy storage systems. For this modeling cycle, we intend to add projects for adoption of battery energy storage within the buildings sector, focusing primarily on the residential sector, and the effect these systems have on electricity supply and prices. This effort is a cross-module interaction that has not previously existed

within NEMS. The report we received and published on distributed generation contains information about a wide range of technologies. It investigates both paired and standalone solar photovoltaics and battery energy storage systems within the residential and commercial sectors. In addition, it characterizes equipment costs for these technologies, as well as small-scale solar photovoltaic (PV), distributed wind, fuel cells, and combined-heat-and-power equipment such as natural gas reciprocating engines and microturbines. We use these data, and findings from other reports, to update our technology choice menus.

We plan to use our PV adoption-choice models to determine battery storage adoption. We have partially based these decisions on data from Lawrence Berkeley National Laboratory's most recent *Tracking the Sun* report, which indicates that more residential than commercial systems are installed with storage and that, most often, battery storage is installed alongside new PV systems or alongside PV capacity upgrades.

In March 2023, we published the most recent version of our contractor report on *Updated Buildings Sector Appliance and Equipment Costs and Efficiencies*. The report contains data for the residential and commercial sectors, and it covers an advanced case and a Reference case, which include data for the current state of each technology and how we expect it to change over time. The data from the report are used to update our technology menus where different technologies and fuels are chosen in NEMS. For AEO2025, we plan to explicitly characterize mini-split air-source heat pumps within the residential module using this report as well as new *2020 Residential Energy Consumption Survey* (RECS) data. We highlighted the efficiency improvements indicated in these reports relative to the report released five years ago.

Beyond AEO2025, we have additional upgrades we plan to make to our buildings modules, depending on funding and data availability. We are working on acquiring data for:

- Residential equipment fuel and technology switching costs
- Thermal energy storage (including standalone, equipment-integrated, and envelope-integrated technologies)
- Updated building envelope data (such as heating and cooling loads, construction costs, and weatherization effects)
- Effects of hydrogen blending on end-use equipment

Policy modeling

The buildings team closely follows federal minimum efficiency standards and ENERGY STAR specifications to inform our modeling of end-use equipment in buildings. Since AEO2023, a number of updated standards have been published for technologies such as furnaces, water heaters, cooking products, pool pumps, and transformers. The updated standards will supersede some assumptions from our technology reports. For example, since the publication of the latest major end-use technology report, the U.S. Department of Energy (DOE) has updated the federal efficiency standard for residential gas-fired furnaces, which will essentially require high-efficiency condensing technology. New standards will also shift the baselines for ENERGY STAR specifications.

We also follow energy-efficiency incentives closely. We use data from the Consortium for Energy Efficiency and program summaries from the U.S. Environmental Protection Agency. In addition, we fund

the Northeast Regional Energy Efficiency Database to help inform our assumptions about measure-level energy-efficiency incentives.

The Inflation Reduction Act continues to be an important factor in our modeling. For AEO2023, we incorporated the extension of existing tax credits for solar PV, small wind, end-use equipment, and combined-heat-and-power systems. As part of our AEO2025 work, we continue to monitor and find ways to include other rebates and tax credits. Our modules do not currently allow explicit representation of programs directed at specific income segments such as low income. Income segmentation is an area of research for us, and we will continue to consider how we might model impacts of income-specific programs.

RECS and CBECS updates

The *Residential Energy Consumption Survey* (RECS) and *Commercial Buildings Energy Consumption Survey* (CBECS) are major inputs to NEMS. Each is used to characterize the base year of the respective NEMS end-use sector modules. For AEO2025, the residential sector base year will be updated from 2015 to 2020, and the commercial sector base year will be updated from 2012 to 2018. In addition to RECS and CBECS, we also benchmark our sector-level energy consumption to historical data sources to ensure we characterize all energy use attributable to the buildings sectors.

Lastly, we briefly discussed data center energy consumption. We account for data center demand inherent in the CBECS, though data centers are not a distinct building type in the survey or in our NEMS commercial module. Data center servers are part of commercial computing energy use in NEMS. We model on-premise data centers as a subset of large office floorspace, and we model incremental increases in energy intensity for cooling, ventilation, and miscellaneous electric loads. For AEO2025, data centers are likely to be represented as a subset of floorspace across *multiple* building types, based on the presence of data center floorspace indicated in the 2018 CBECS microdata.

Discussion

During the presentation, a participant submitted a question on how low carbon fuels, renewable natural gas, and methane/hydrogen blends are represented within NEMS as potential fuels that could be distributed through existing natural gas infrastructure serving the buildings sector. We explained that the hydrogen market modeling group will address the question. We do not plan to explicitly model hydrogen within buildings for AEO2025, although hydrogen blending is an active area of research for the team.

A second question was submitted during the presentation, which was about commercial and residential hybrid-gas furnaces and electric heat pump products that mainstream HVAC manufacturers are introducing and how we might be able to model such systems within NEMS. We responded that we model equipment that we can develop cost and performance characteristics for. We model air- and ground-source heat pumps; however, those systems are currently fuel-specific, and we do not currently model hybrid systems.

A participant asked about space heating electrification in both the residential and commercial demand modules. Specifically, the participant was interested in how NEMS represents equipment type, what the impacts on peak demand are, and how the grid responds. The team explained that we use RECS and CBECS microdata to gain insight into building energy electricity use. In addition, the technology report

data represents all technologies used in our projections. Based on these sources, we incorporated a wide range of technologies into model inputs, which are then combined in our technology menu with costs, incentives, hurdle rates, and equivalent replacement or upgrade choices. All of these factors drive the mix of modeled equipment stock over time, which ultimately determines electricity demand. From there, demand is sent to the supply side of NEMS. We do not account for peak energy demand or related equipment choices in the residential or commercial buildings modules.

A participant asked how behind-the-meter battery storage would affect electricity load shapes. We explained that the participant should stay tuned for future information and that behind-the-meter storage impacts on load shapes would likely be handled by the NEMS Electricity Market Module.

A participant requested information about how we will incorporate the HOME Investment Partnership Program into NEMS and suggested that all households may be eligible for energy-efficiency upgrade funds. We clarified that this program is an active area of interest but the broad scope of the program makes it complicated to model in NEMS. As an example, we do not explicitly model floorspace within the residential sector, so determining how to attribute certain kinds of programs that are designed to save energy is challenging.

We also accepted questions during the working group registration process. A participant submitted a question about whether we model specific devices within NEMS. We explained that we develop device service demand intensity from RECS and CBECS microdata. Technology reports provide different levels of detail on various aspects of equipment. We also use the *Miscellaneous Electric Loads Report,* which provides the consumption and stock of devices such as laptops, tablets, and pool heaters. We combine the data from each of these sources to multiply the equipment stock by its unit energy consumption based on its power draw. This calculation is more of an assumption fed into our model rather than an endogenous technology-level choice. In general, we try to represent technologies with ENERGY STAR specifications and federal minimum energy-efficiency standards.

A participant asked about whether virtual power plants are modeled in NEMS. We explained that these plants are neither modeled as part of our buildings projections nor as part of the electric power sector module in NEMS.

As a follow-up question about how we model technologies, a participant asked how modelers decide to incorporate new technologies in NEMS. The participant wondered if we base these decisions on market share, performance, cost, or other factors and, in addition, if the team could use research and development data that characterizes emerging equipment performance. We explained that we are always interested in learning more about new technologies. Because NEMS is a long-term model, we understand that a lot can change over the 30-year span covered by the AEO, but NEMS has generally been more of an evolutionary model than a revolutionary one. As such, we focus more on commercialized products that are currently on the market because they already have an installed base that we can quantify based on RECS, CBECS, and technology reports. Some of these technologies may be relatively new to the market. For example, solar PV may be considered mature or *nascent*, and the technology is still improving. We have current data to use when incorporating these types of technologies into NEMS. We also shared that although the AEO Reference case primarily covers existing technologies, we have, in the past, run a few side cases to investigate the effects of technologies still in

development or nearly on the market. With all the other data updates currently underway, we do not expect to model additional technologies for AEO2025.

A participant asked about stacking the commercial utility rebate program and IRA funding for multifamily buildings where both are possible to use. We account for stacking federal rebates and non-federal incentives for eligible equipment. We clarified that multifamily housing units are represented in the residential module, but we recognize that some of those buildings behave more like commercial buildings in terms of how they are heated and cooled.

A participant asked how district heating is represented within our models. We explained that district heating and cooling is represented in the commercial sector, and users can view the data in the commercial tables. We also offered to share additional district heat information with the participant.

A participant asked when regulations are incorporated into NEMS, when finalized or in the draft stage. The team shared that we model the effect of regulations that are finalized and enforceable, including those set to take effect in the coming years.

The final question was about whether we include demand response payments and energy-efficiency resources, which are offered at the Independent System Operators and Regional Transmission Organizations grid level, within incentive modeling. We explained that we include the publicly available data sources compiled by the Consortium for Energy Efficiency and EPA in our estimated incentive averages for each census division.

Attendees

Name	*Affiliation*
Alyssa Leibold	Bureau of Labor Statistics
Paula Ham-Su	DNV
Colin Cunliff	DOE
Eric Goode	DOE
Jun Shepherd	DOE
Michael Cham	Encentive Energy
Beth Conlin	EPA
Ansh Nasta	GTI Energy
Derek Wissmiller	GTI Energy
Douglas Kosar	GTI Energy
Matthew Ives	GTI Energy
Ram Dharmarajan	GTI Energy
John Meyer	Leidos
Matthew Cleaver	Leidos
Peter Kobylarek	Leidos
Chioke Harris	NREL
Jack Mayernik	NREL
Wesley Cole	NREL
Frances Wood	OnLocation, Inc
Robert Hershey	Private Consultant
Hannah Kolus	Rhodium Group
John Agan	U.S. Department of Energy (DOE)
Jennifer Lake	World Resources Institute

EIA staff attendees

Monica Abboud
Stacey Angel
Tuncay Alparslan
James Berry
Erin Boedecker
Richard Bowers
Singfoong Cheah
Rosalie Dubbohlke
Michael Dwyer
Timothy Hess
Tyler Hodge
Sarah Grady
Peter Gross
Kevin Jarzomski
Christina Jenq
Mala Kline
Greg Lawson
Janice Lent
Nilay Manzagol
John Maples
Zachary Marohl
Laura Martin
Joelle Michaels
Kevin Nakolan
Jay Olsen
Boon Teck Ong
Catherine Prendergast
Mark Schipper
Elizabeth Sendich
Sauleh Siddiqui
Nicholas Skarzynski
Courtney Sourmehi
Manussawee Sukunta
Josh Whitlinger