Independent Statistics and Analysis
U.S. Energy Information Administration

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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 November 13, 2024

This memorandum provides an overview of the second *Annual Energy Outlook 2025* (AEO2025) Buildings Working Group presentation and summarizes the discussion of the modeling and data updates that were accomplished for AEO2025. The presentation is available in a separate document.

AEO2025 Results Overview

We presented the AEO2025 Reference case as of November 2024. In the residential sector, natural gas consumption decreases between 2024 and 2050, partly due to updated federal standards requiring higher energy efficiency for natural gas equipment. Residential and commercial electricity use increases between 2024 and 2050 due to growing space-cooling demand and rising miscellaneous electric loads. Electricity use in on-premise data centers contributes to growing natural gas consumption in the commercial sector. Commercial natural gas increases between 2024 and 2050. Natural gas use increases slower than commercial floorspace increases due to decreasing heating demand and improving efficiency.

The Electricity Market Module (EMM) now attributes electricity sales related to electric-vehicle (EV) charging to the residential and commercial buildings sectors so that electricity prices can reflect the sector where charging happens. As a result, transportation sector electricity sales for AEO2025 are lower than in AEO2023. These changes are accounting related. We still model EV purchases and energy use in the Transportation Demand Module, and we allocate the resulting electricity sales in the EMM.

We updated the heating and cooling degree day projections that affect space-heating and cooling consumption in both the Residential Demand Module (RDM) and the Commercial Demand Module (CDM). In preliminary AEO2025 results, near-term heating degree days decrease, and cooling degree days increase relative to AEO2023 due to two additional years of historical weather data from the National Oceanic and Atmospheric Administration (NOAA). Additional updates from what we presented are forthcoming. Consistent with changes to the *Short-Term Energy Outlook* (STEO), we no longer use

NOAA's 15-month short-term forecast before implementing a 30-year historical trend for degree day projections.

We developed our projections for residential housing starts from the S&P Global U.S. Macroeconomic Model. AEO2025 housing stocks reflect a slowdown of housing starts, although we still project more housing stock than in AEO2023. We project commercial floorspace to grow from 2024 to 2050. Warehouses, health care, lodging, and other buildings all grow faster than the average in our AEO2025 projections.

CBECS and RECS Technology and Policy Representation

The updates to the 2018 *Commercial Buildings Energy Consumption Survey* (CBECS) and the 2020 *Residential Energy Consumption Survey* (RECS) estimates affect virtually every aspect of the National Energy Modeling System's (NEMS) residential and commercial demand modules. These surveys show a snapshot of historical data that forms the base year for our residential and commercial buildings projections. Some differences between the surveys and our model results are definitional; for example, CBECS does not cover non-building uses, and RECS does not include vacation homes. Methodological updates incorporate advances in end-use models as well as changes in how energy use is distributed in the commercial and residential sectors. We benchmark our historical data to a number of sources, including EIA's State Energy Data System, *Monthly Energy Review*, and *Short-Term Energy Outlook*.

Our latest projections use updated technology menus based on the most recent *Updated Buildings Sector Appliance and Equipment Costs and Efficiencies* report. Increasing electricity use is driven, in part, by our expanded representation of on-premise data centers in the commercial sector. On the residential side, we project an overall decline in end-use energy consumption through 2050. Changes to federal minimum efficiency standards broadly improve efficiency for most appliances; water heating, in particular, demonstrates this effect. We updated assumptions to reflect the latest ENERGY STAR specifications. Residential natural gas-fired furnaces will require high-efficiency condensing equipment starting in December 2028. This change is the largest in furnace efficiency in nearly a decade. Residential water heating standards go into effect in 2029, requiring more-efficient natural gas equipment and heat pump technology for electric storage water heaters.

We use both capital costs and operating costs in our consumer choice modeling and use appliance betas to form an implicit discount rate that weighs the up-front cost against long-term savings. These appliance betas directly affect choice within our technology menus. We calculate betas by efficiency level within a given technology class, deriving the proportion of high efficiency units from shipment data. The biggest shift from earlier AEOs was in the water heater category. We had been over-estimating high-efficiency equipment shipments. This area is subject to ongoing research, and we will continue to improve these projections for future AEOs.

We incorporated updated cost and performance characteristics for distributed generation technologies based on an updated distributed generation report. We have not changed how we model residential solar photovoltaic (PV) adoption. However, we have incorporated recent data to reflect the latest installation rates across the United States, increasing projections relative to AEO2023. On the commercial side, preliminary results show how a significant single-year drop in the electricity price for commercial consumers put downward pressure on the potential for new builds. We expect final AEO2025 projections for solar PV generation and capacity to generally increase along historical trends.

We develop Bass diffusion parameters, based on historical market conditions and activity, to shape and scale growth in commercial sector distributed generation and combined-heat-and-power (CHP) technology adoption.

In NEMS, ENERGY STAR and Consortium for Energy Efficiency summaries form the basis for modeling the effects of census division-level average rebate savings in offsetting building equipment costs. We project differences in average rebate values across the United States. The New England and Pacific Census Divisions tend to have above-average rebate values for electric equipment, and the West South Central Census Division has notable rebates for heat pumps. We do not represent midstream incentives except to the extent that they implicitly affect the installed cost of the equipment.

On-premise data center characterization

In NEMS, we historically characterized data centers in large office buildings. For AEO2025, we used CBECS microdata to expand data center representation across the commercial buildings stock, and we included on-premise data center rooms in 8 of 11 NEMS building types. Data-center floorspace requires additional space cooling, ventilation, and computing power relative to other floorspace. For AEO2025, we use a lower base to compute energy use than for the previous AEO. However, we project faster growth through 2050. Historical differences reflect recent efficiency trends, and projected growth can be largely attributed to expanding data centers.

We do not explicitly model stand-alone data centers or cryptomining, which we would likely characterize as a miscellaneous electric load, in NEMS. Our historical energy-supply data sources reflect energy consumption at the sector level, so energy use by existing stand-alone data centers and cryptomining enterprises is included in "Other consumption."

Beyond AEO2025

We postponed modeling behind-the-meter battery storage to allow us to develop a method consistent with the planned update for the residential solar PV adoption model. We are administering two contractor tasks: one characterizing residential fuel switching costs and another scoping the use of thermal energy storage in stand-alone equipment, integrated equipment, and envelope-integrated equipment in both the commercial and residential sectors. In future modeling cycles, we plan to develop detailed parametric energy analysis of building shell improvements and their effects on building heating and cooling loads and residential construction costs, and we also plan to account for changes in residential weatherization. These updates will expand our ability to model new policies. We continue to investigate the effects of hydrogen blending on end-use space and water heating consumption.

Discussion

During the Q&A portion of the meeting, a participant asked about the CDM representation of data centers and whether it includes industrial-scale data. We explained that projections account for on-premise data centers. We don't have sufficient data to reliably and *explicitly* model stand-alone data centers for AEO2025, but our projections represent all commercial sector activities. NEMS uses the North American Industry Classification System (NAICS) to form our sector definitions. Unless the NAICS codes associated with data centers change, we expect that data centers, no matter how energy-intensive or large, will be modeled in the commercial sector.

Next, a participant asked if we could clarify the change in the results of using appliance betas for modeling consumer behavior. We explained that the betas do not change the total number of purchased equipment, such as water heaters. Rather, they change the proportion of high-efficiency to low-efficiency units within a given equipment class. So, it changes the stock average efficiency, which is the primary driver for changes in consumption. A few technologies shifted in average efficiency, such as water heaters and clothes dryers.

A participant stated that data centers are unique because they have a flat load shape. The participant asked about the possible implementation of any load-shape changes for increased data-center demand. We replied that load shapes are managed in the EMM. The buildings modules project annual energy consumption and efficiency rather than hourly, and electricity supply modelers have updated load shapes this year, including for computing.

A participant asked what changes we made to the methodology of the hurdle model. We explained that we did not change the methodology, but we did update the inputs to the hurdle model to use 2022 historical data.

A participant asked if the PV hurdle model accounts for NEM 3.0 in California. We explained that it does not explicitly account for it, but we are following those developments.

A participant asked about changes in residential electric loads in 2020 between AEO2023 and AEO2025 and about the impact of the new billing calibration method used in the latest RECS on fuel splits at the census division level in the first few years of the AEO. We shared that we made some end-use changes as a result of incorporating the 2020 RECS. For example, furnace fan energy consumption reflected revisions in RECS end-use modeling assumptions. We offered to follow up with the stakeholder after the meeting.

A participant asked for clarification on the driving forces behind the increase in energy consumption by data centers and whether it was primarily due to intensity assumptions for the “Other” building type or increasing floorspace for “Other” buildings. We explained that we implemented incremental increases in intensity for all relevant building types and calibrated the share of floorspace that operates like a data center room across these building types, including “Other.” We did not change the growth rate for commercial floorspace, but we did assume that a higher share of floorspace across commercial spaces operates like a data center.

A participant asked about the commercial “Other MELs” (miscellaneous electric load) category in NEMS. The participant asked why consumption within this category triples by 2050. We clarified that “characterized MELs” are MELs that are explicitly accounted for, such as energy consumed by uninterruptible power supplies. “Other MELs” represent things that we haven’t modeled explicitly but we know consume energy, including equipment you would expect to increase with computing.

A participant asked about if chargers installed in buildings would be counted as a building consumption load. We explained the electricity used to charge an EV is ultimately attributed to the transportation sector, but the EV reporting updates show where vehicles are assumed to be charged. In addition, charging location factors into electricity prices. The transportation working group meeting may provide more information about this.

After the presentation, a participant followed up with our team via email to ask if we were incorporating the National Renewable Energy Laboratory's (NREL) dGen model into our solar modeling. We explained that we are not using the NREL model; we use an EIA-developed exogenous hurdle model. The participant followed up to discuss the incorporation of NEM 3.0 in California, and the impact it has had on solar adoption. We expressed that NEMS operates at the census division level, so our models do not directly include any state-specific policies. We also explained that we are still developing our approach to modeling behind-the-meter battery storage, and we are tracking the impacts of policies such as NEM 3.0.

Attendees

Name	*Affiliation*
David Adler	Congressional Budget Office
Michael Cham	Encentiv Energy
Ramanathan Dharmarajan	GTI Energy
Yuting Chen	Lawrence Berkeley National Laboratory
Jared Langevin	Lawrence Berkeley National Laboratory
Margaret Pigman	Lawrence Berkeley National Laboratory
Eric Wilson	Lawrence Berkeley National Laboratory
Hung-Chia Yang	Lawrence Berkeley National Laboratory
John Meyer	Leidos
Wesley Cole	National Renewable Energy It Laboratory
Katelyn Stenger	National Renewable Energy Laboratory
Andrew Speake	National Renewable Energy Laboratory
Hao Deng	OnLocation, Inc.
Amogh Prabhu	OnLocation, Inc.
Sharon Showalter	OnLocation, Inc.
Frances Wood	OnLocation, Inc.
Alan Cooke	Pacific Northwest National Laboratory
Robert Hershey	Private Consultant
Hannah Kolus	Rhodium Group
Anna van Brummen	Rhodium Group
Glen Salas	Simonson Management Services
Justin Baca	Solar Energy Industries Association
Colin Smith	Solar Energy Industries Association
Tyler Thompson	Solar Energy Industries Association
Glenda Oskar	U.S. Department of Energy
Jason Frost	U.S. Department of Energy
Beth Conlin	U.S. Environmental Protection Agency

EIA staff attendees

Stacy Angel
Jeffrey Bennett
Erin Boedecker (Presenter)
Francisco Cifuentes
Jim Diefenderfer
Rosalie Dubbohlke (Presenter)
Kathryn Dyl
Sarah Grady
Peter Gross
Tyler Hodge
Kevin Jarzomski (Presenter)
Mala Kline
Greg Lawson
Janice Lent
Nilay Manzagol
Laura Martin
William McNary
Ian Mead
Joelle Michaels
Kevin Nakolan
Christopher Namovicz
Jay Olsen
Kelly Perl
Corrina Ricker
Emily Schaal (Presenter)
Matthew Skelton
Courtney Sourmehi (Presenter)
Manussawee Sukunta
Rubaiyat Tasnim