AEO2025 Working Group Meeting II

Residential and Commercial Buildings

Energy Consumption and Efficiency Modeling Team
November 13, 2024 | Virtual

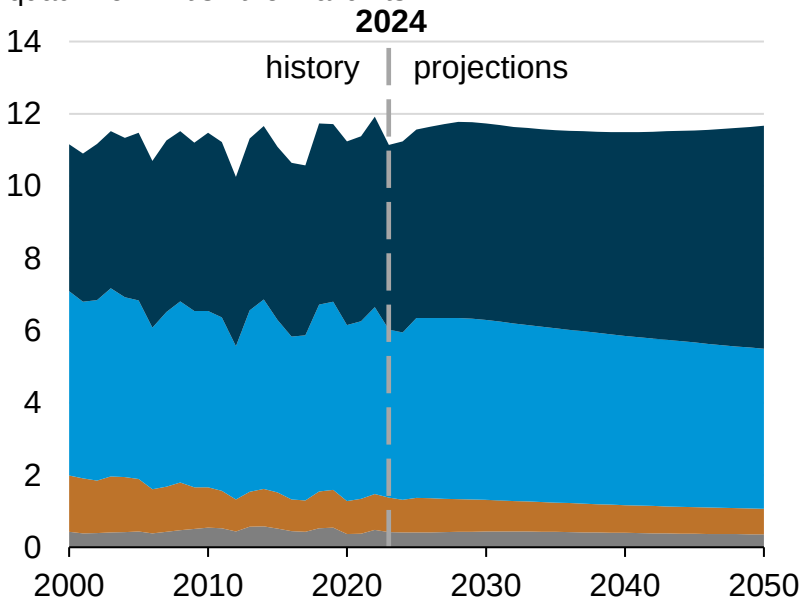
Overview

- *Annual Energy Outlook 2025* (AEO2025) preliminary results overview
- Changes in the residential and commercial buildings sectors
  - *Commercial Buildings Energy Consumption Survey* (CBECS)
  - *Residential Energy Consumption Survey* (RECS)
- Impacts of implemented updates
  - Technology representation
    - Major end-use technology updates
    - Distributed generation technology updates
  - Policy representation
    - Recent legislation and policy assumptions
  - On-premise data center characterization

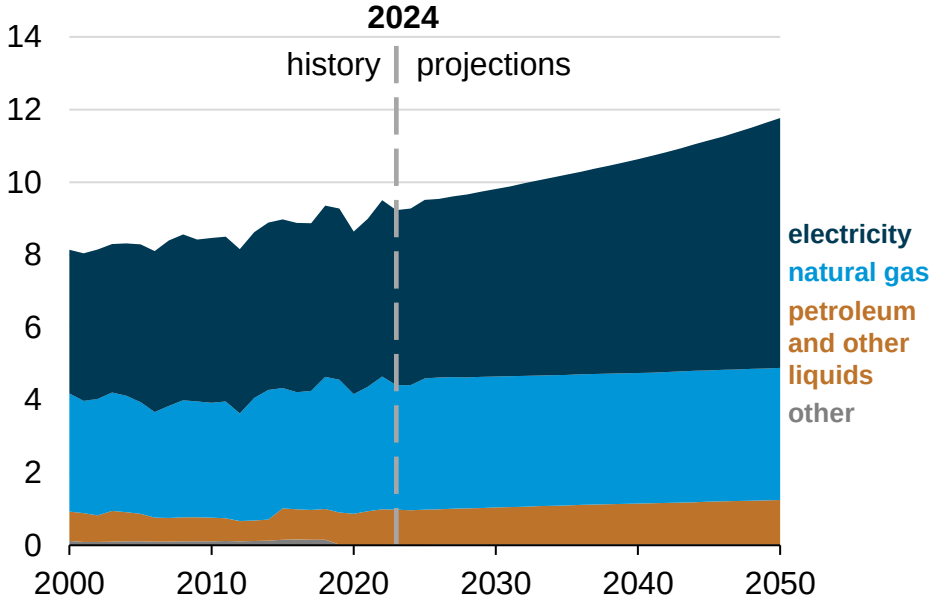
AEO2025 Preliminary Results Overview

Future standards contribute to decreasing residential natural gas while commercial electricity reflects updated assumptions for data centers

Residential sector energy consumption
AEO2025 Reference case
quadrillion British thermal units



Commercial sector energy consumption
AEO2025 Reference case
quadrillion British thermal units



Data source: AEO2025 preliminary

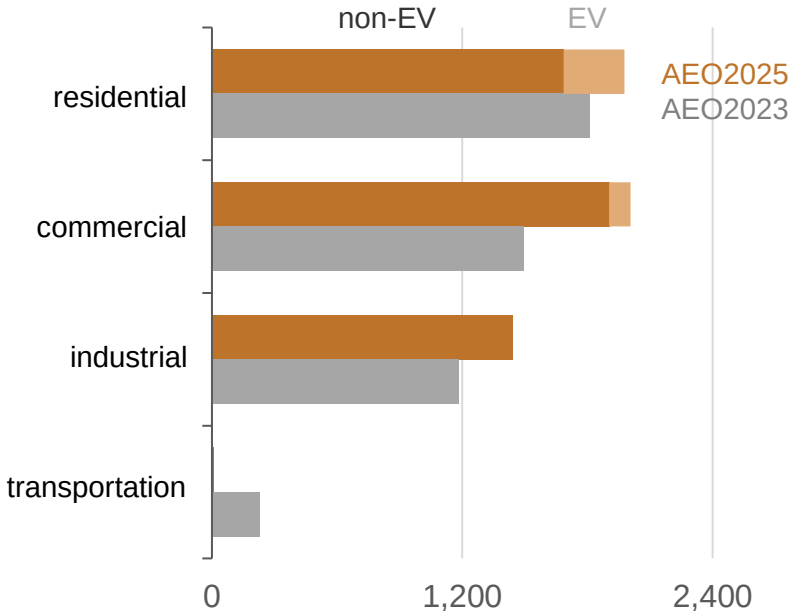
Note: Includes purchased electricity and on-site generation for own use

For AEO2025, electric vehicle consumption will be attributed to individual buildings end-use sectors

- Reflecting EV-related electricity sales within the buildings sectors improves supply-side accounting of electricity prices
- Emissions still attributed to the transportation sector
- Modeling and accounting still occur within transportation and electricity supply models (not within buildings models)

Electricity sales by sector, 2050

billion kilowatthours

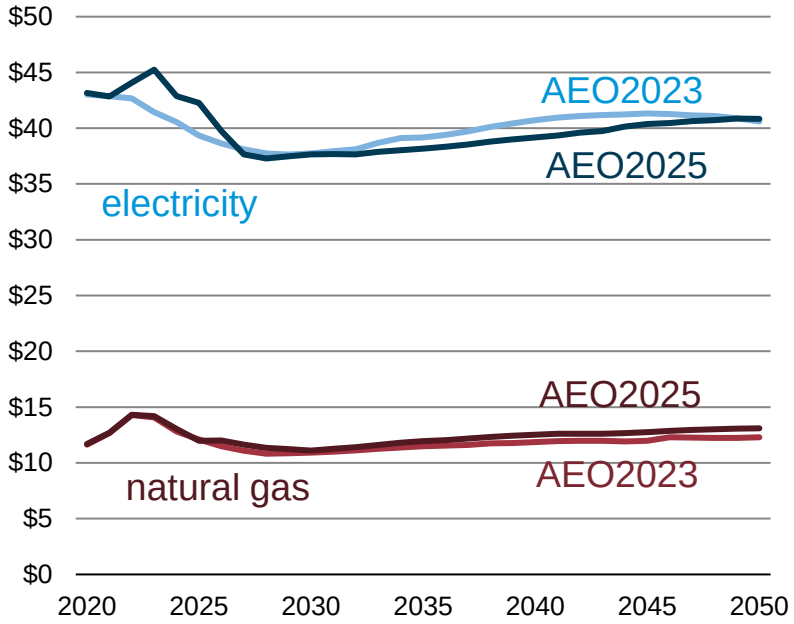


Data source: AEO2023 Reference case; AEO2025 preliminary

Electricity prices reflect supply-side changes for AEO2025

Residential fuel prices

2022 $/MMBtu



Commercial fuel prices

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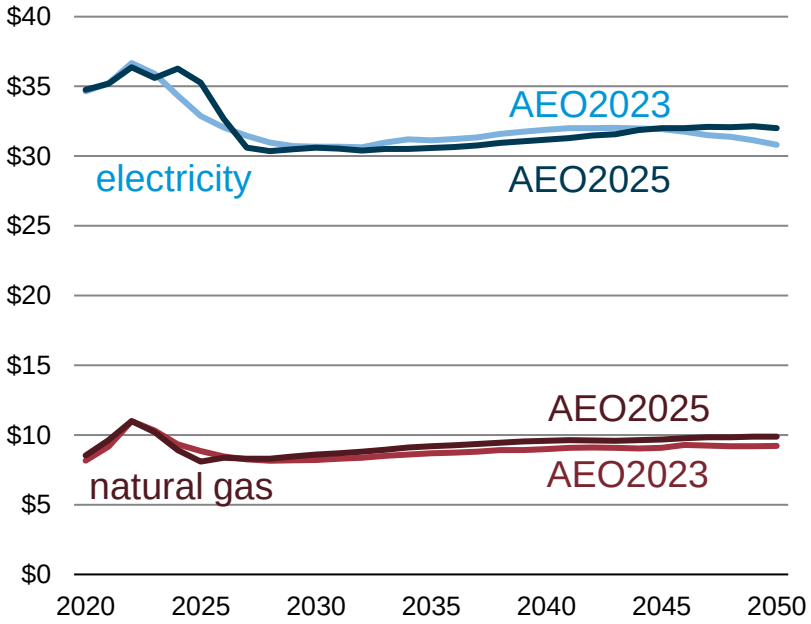
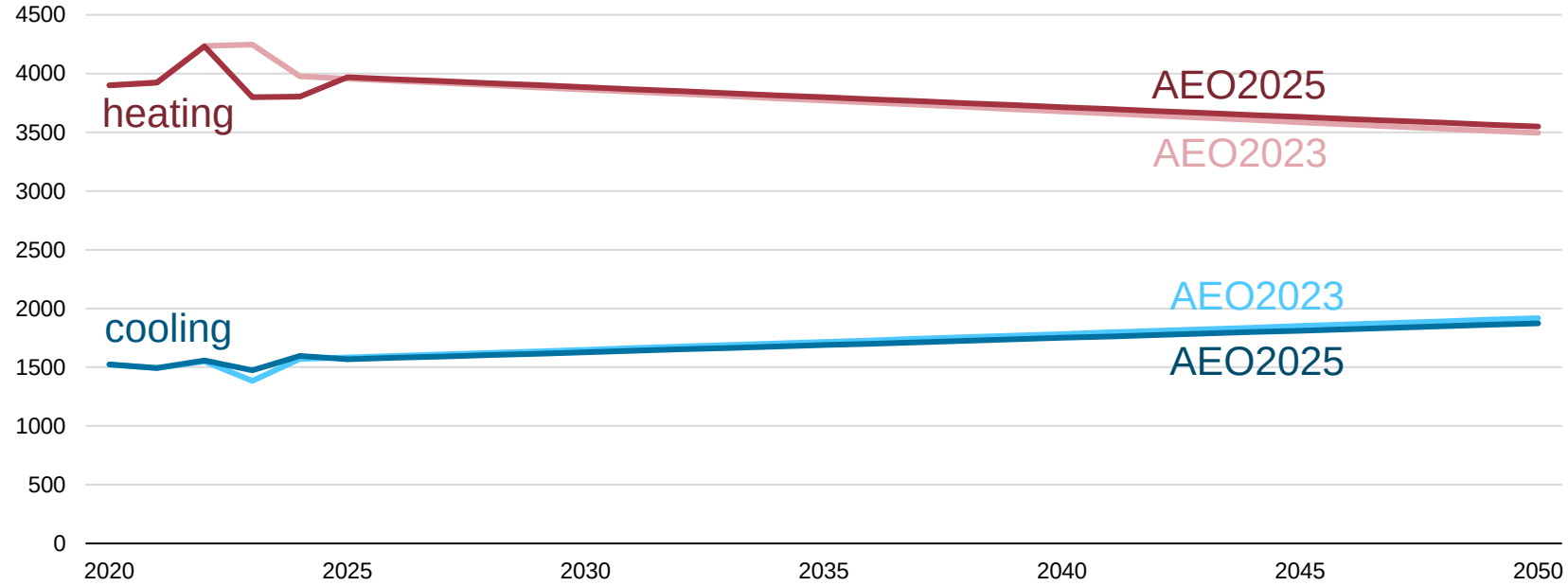


Data source: AEO2023 Reference case; AEO2025 preliminary

Heating and cooling degree days include NOAA historical data and 30-year trend through projection period

Weather trends in the the AEO Reference case

population-weighted degree days



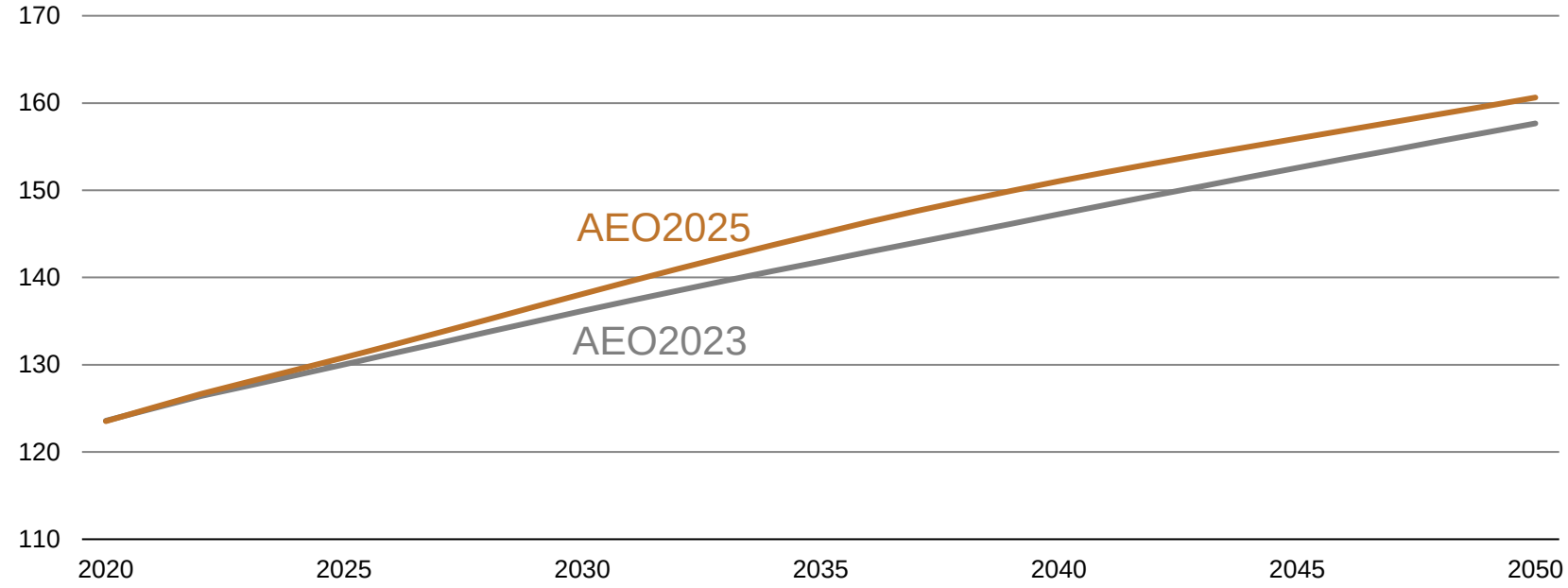
Data source: AEO2023 Reference case; AEO2025 preliminary

Note: NOAA refers to the National Oceanic and Atmospheric Administration.

Residential housing *starts* slow down between 2030 and 2045, but projected stocks still higher than AEO2023

Total households in the residential building sector

millions

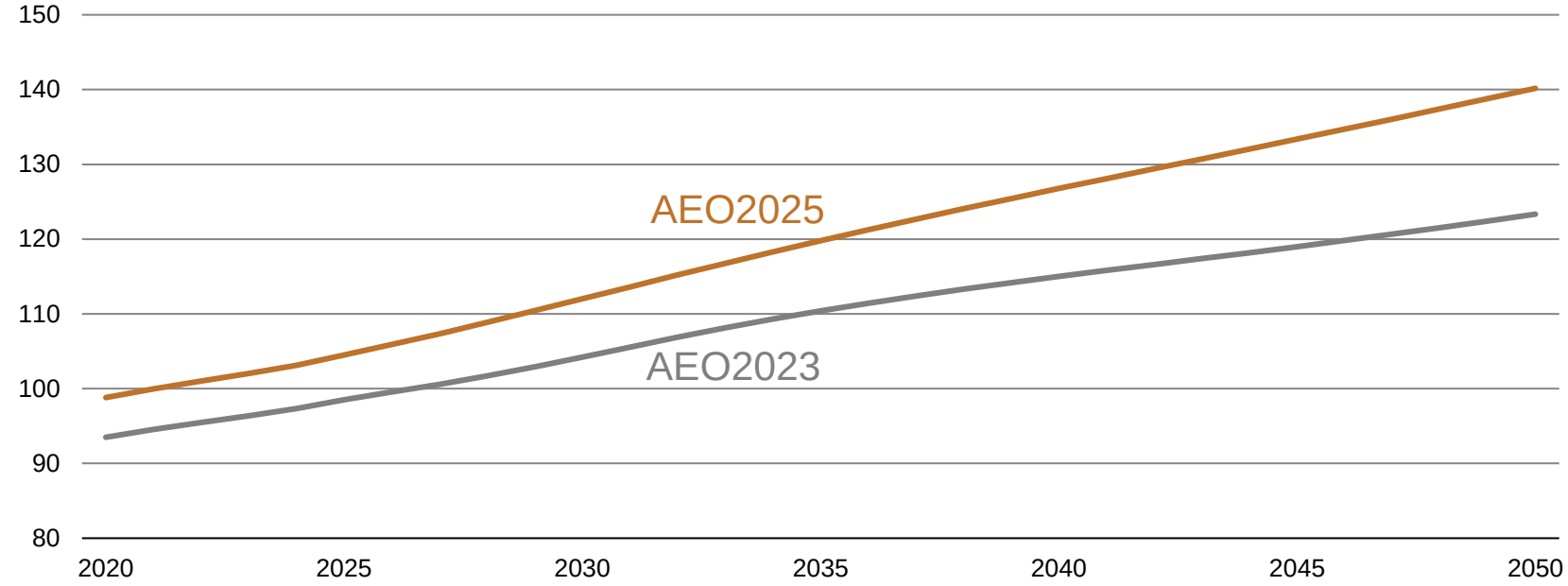


Data source: AEO2023 Reference case; AEO2025 preliminary

Commercial floorspace revised upward as part of 2018 CBECS update

Total floorspace in the commercial sector

billion square feet



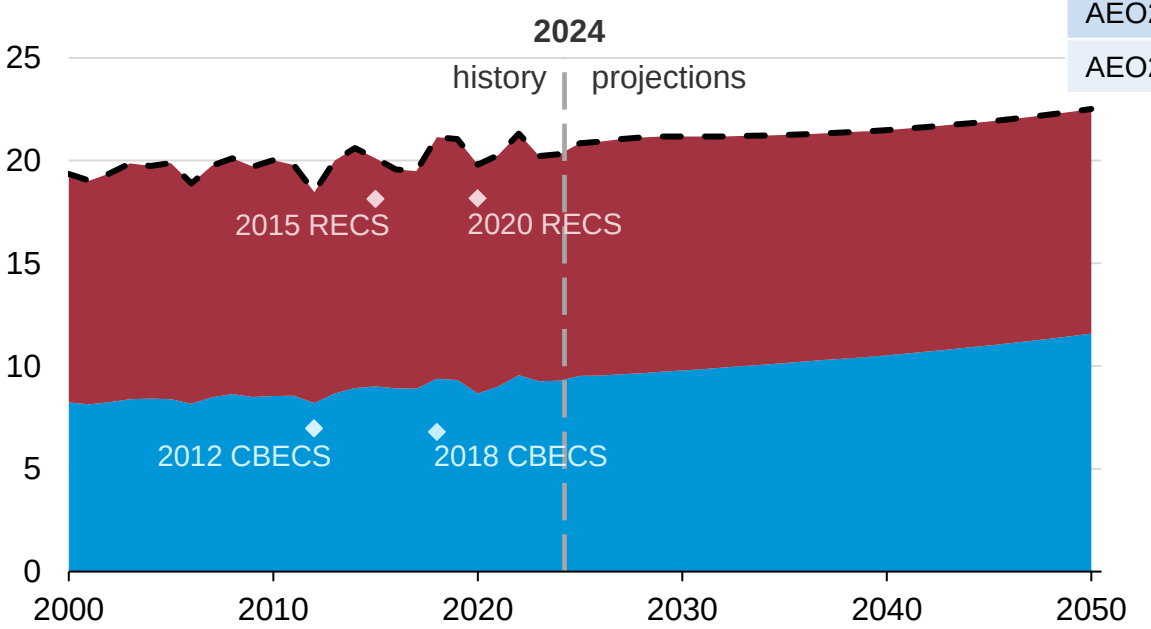
Data source: AEO2023 Reference case; AEO2025 preliminary

Major AEO2025 Updates:
CBECS & RECS
Technology & Policy Representation

EIA consumption surveys do not represent the *entirety* of the residential and commercial buildings sectors

Buildings delivered energy consumption

quadrillion British thermal units

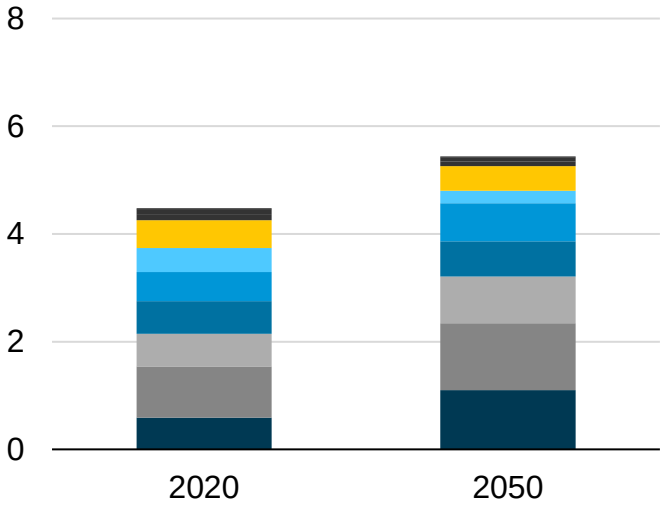


Annual Energy Outlook	*RECS used*	*CBECS used*
AEO2023	2015	2012
AEO2025	2020	2018

Data source: RECS; CBECS; AEO2025 Reference case preliminary

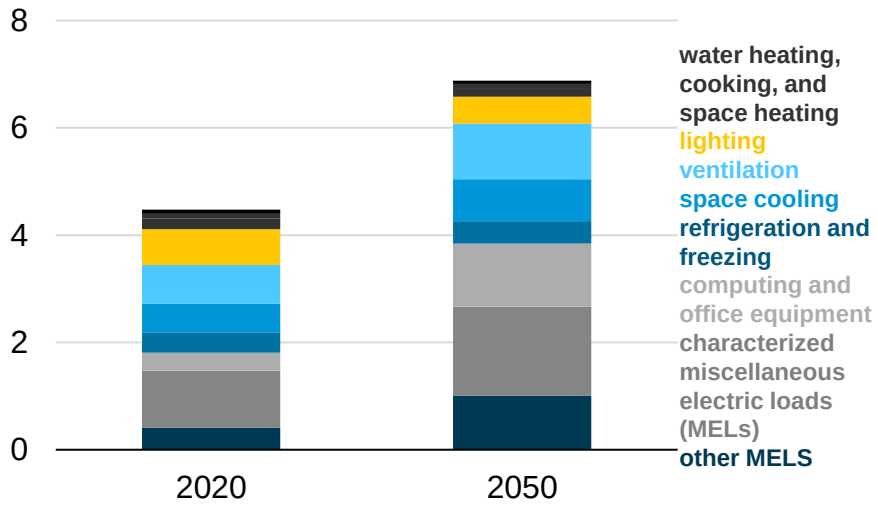
Base year updates and the latest technology cost and performance specifications contribute to significant differences in energy use

Electricity consumed to meet commercial end-use demand
AEO2023 Reference case
quadrillion British thermal units



Data source: AEO2023 Reference case

Electricity consumed to meet commercial end-use demand
AEO2025 Reference case
quadrillion British thermal units



Data source: AEO2025 Reference case preliminary

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Electricity consumed to meet residential end-use demand
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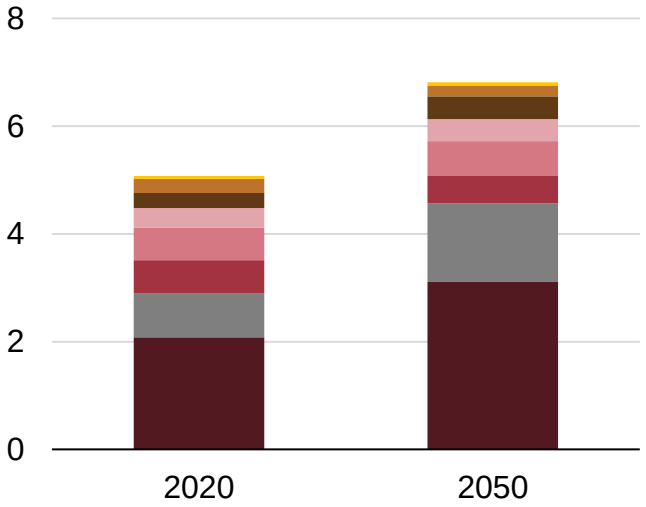
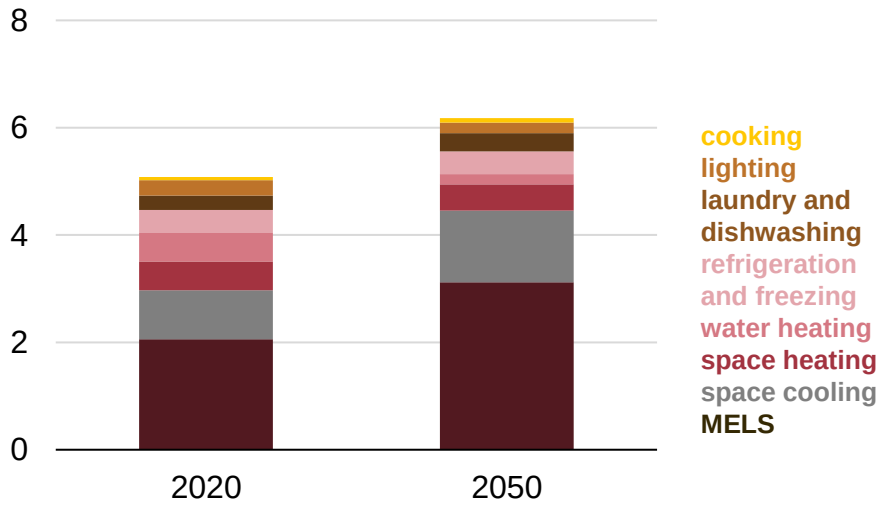


Data source: AEO2023 Reference case

Electricity consumed to meet residential end-use demand
AEO2025 Reference case
quadrillion British thermal units



Data source: AEO2025 Reference case preliminary

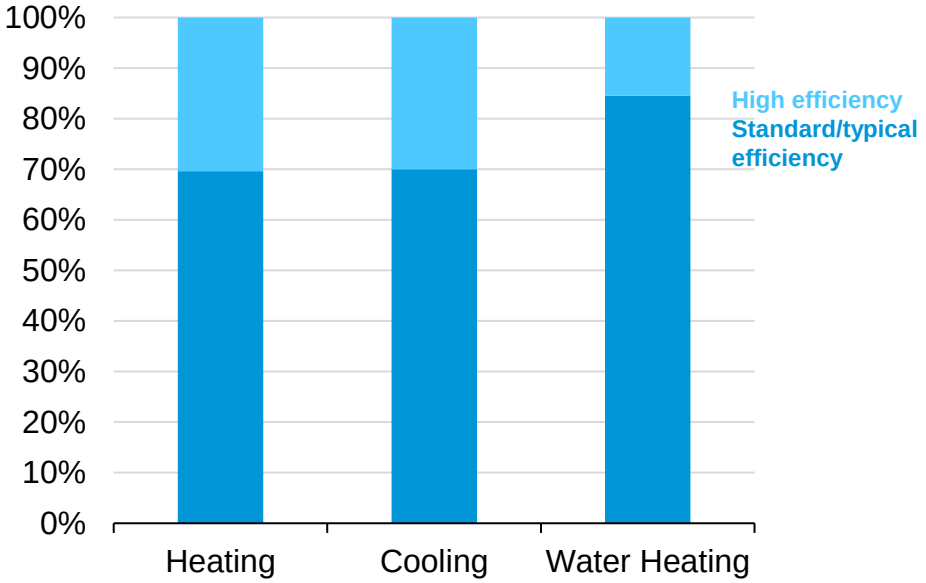
Many updates to federal efficiency standards and ENERGY STAR specifications have been incorporated for AEO2025

- Residential
  - Gas-fired furnaces
  - Room air conditioners
  - Electric and gas-fired water heaters
  - Refrigerators and freezers
  - Clothes Washers
  - Clothes Dryers
  - Dishwashers
  - Conventional cooking equipment
  - Microwaves
- Commercial
  - Rooftop heat pumps and air conditioners
  - Water heaters
  - Refrigerators
  - Ice makers
  - Distribution Transformers
  - Laptop computers
  - Lab refrigerators and freezers

Residential appliance betas are used to align model outputs with historical consumer behavior in purchasing equipment

- Variables in our residential technology menu used to weight consumer choice between capital costs versus operating costs
- Used to form an implicit discount rate
- Revisions based on historical shipment data from contractor technology reports, AHRI, and ENERGY STAR program summaries
- We calculated betas to create a share of high efficiency units out of total units modeled in NEMS that is representative of what our data sources show

Residential technology shares by efficiency level
AEO2025 Reference Case
Percentage of equipment stock in 2021



Data source: AEO2025 preliminary

Recent changes in solar photovoltaic adoption trends push projections upward through 2050

- The residential econometric hurdle model estimates trends in PV installed in 2011–2022 and uses these trends to compute projections of system installs for each ZIP code in the United States for each projection year 2023–2050.

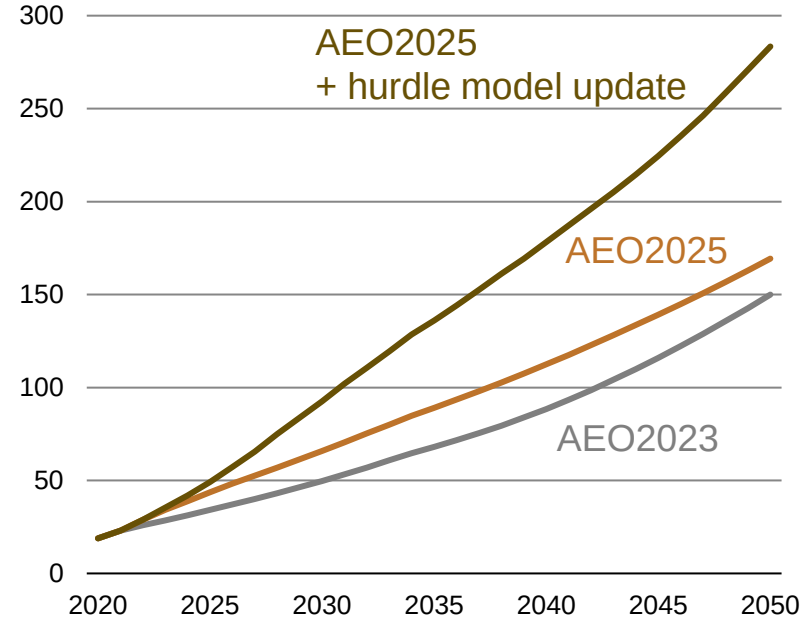
- There are no major changes to methodology from AEO2023.
  - Projected installs = (estimated likelihood of install) x (estimated number of installs)
  - Due to a paucity of PV install data at the ZIP code-level, we compute trends for data states and interpolate those trends to non-data states

- Updating the model to more recent data has pushed projected installs up significantly.
  - Explained by a general rise in install rates across the US from 2021 to 2022

Differences in electricity prices, system characteristics, and social drivers affect buildings PV projections

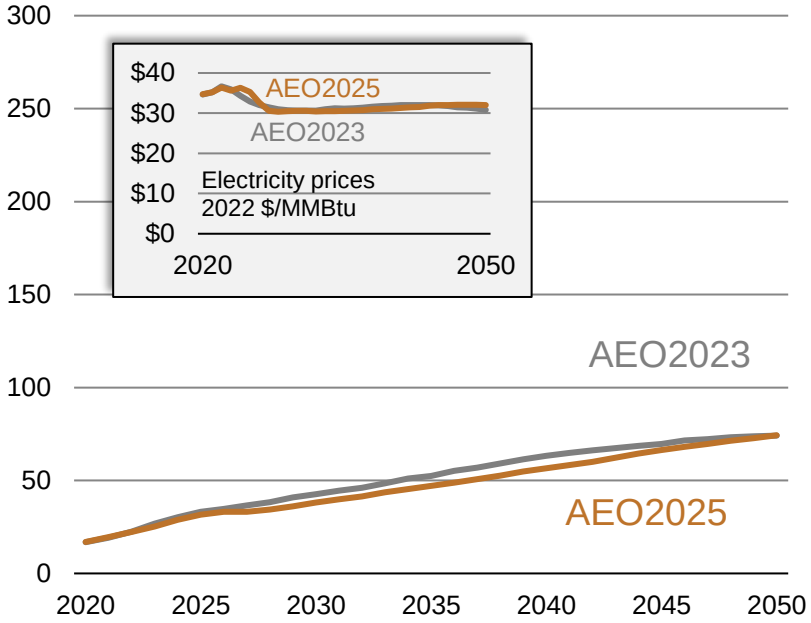
residential PV capacity

gigawatts-direct current (GW-DC)



commercial PV capacity

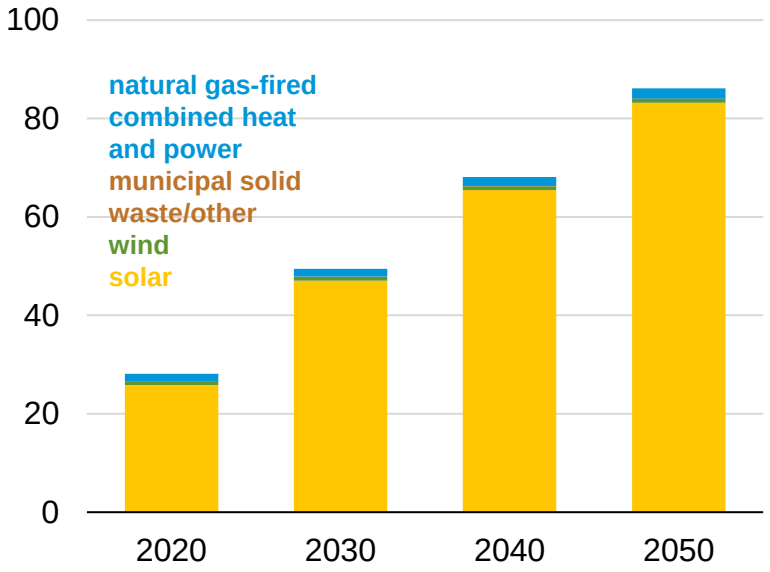
gigawatts-direct current (GW-DC)



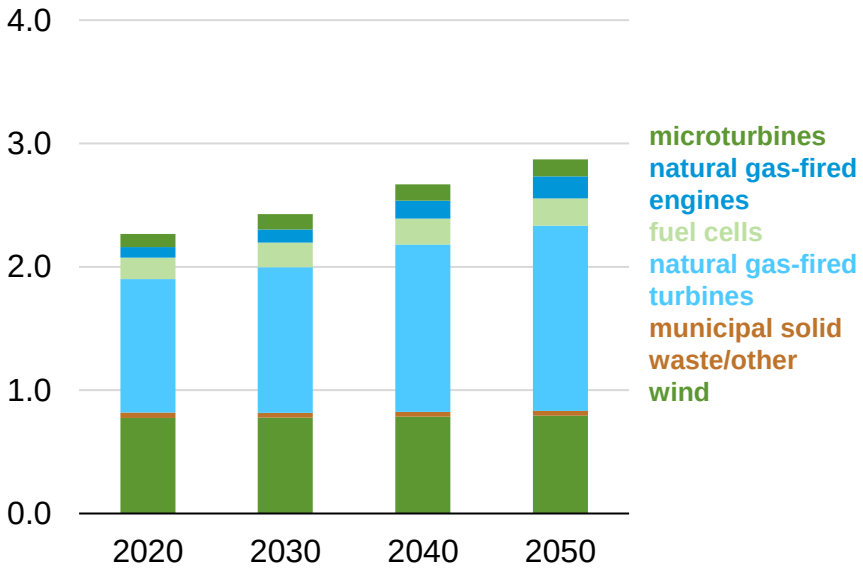
Data source: AEO2023 Reference case; AEO2025 preliminary

On-site electricity generation capacity is largely solar PV, but combined heat and power capacity grows through 2050

Commercial distributed generation capacity
AEO2025 Reference case
gigawatts direct current



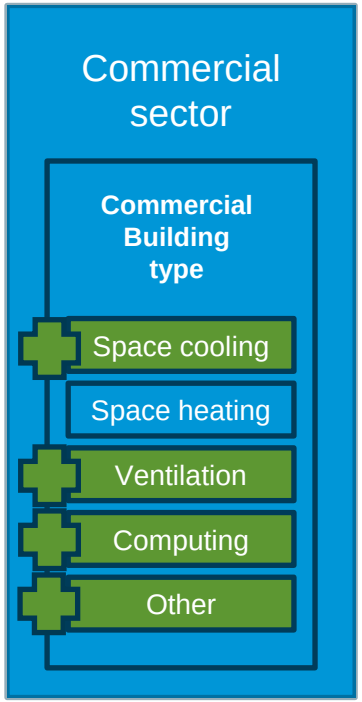
Commercial non-solar distributed generation capacity
AEO2025 Reference case
gigawatts direct current



Data source: AEO2025 preliminary reference case

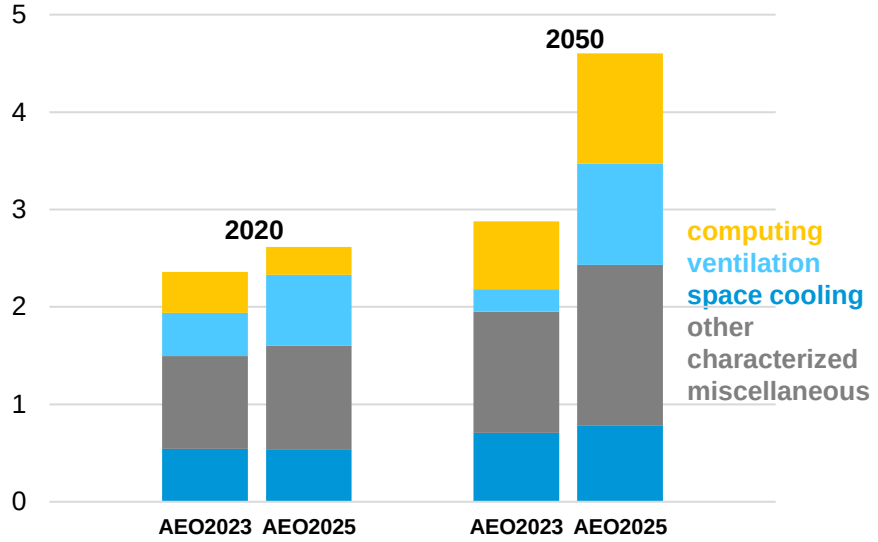
On-premise Data Center Characterization

Data centers are included in our commercial projections



- We expanded on-premise data center representation
- Energy use associated with space cooling, ventilation, computing, and other miscellaneous electric loads (MELs) increases to support data centers

Commercial energy consumption for select end uses
AEO2023 and AEO2025 Reference case
quadrillion British thermal units



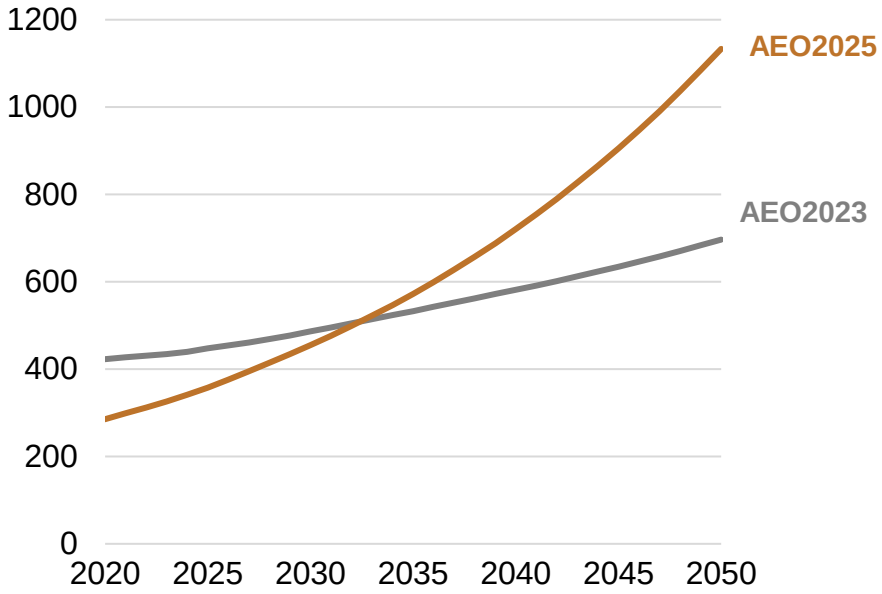
Data source: AEO2023 Reference case and preliminary AEO2025 Reference case

Computing energy use, which includes data center servers, now starts from a lower base relative to AEO2023, but outpaces growth rate significantly

Commercial MEL	AEC (TWh/yr)	Installed Base (000s)*
Kitchen Ventilation	53	1,042
Distribution Transformers	46	5,824
Data Center Servers	46	13,500
Commercial Desktop PCs	31	75,757
Wastewater Treatment*	31	11,886,208
Water Supply & Purification*	29	14,666,269
IT Equipment	15	581,654
Lab Fume Hoods	14	872
Lab Refrigerator and Freezers	11	2,756
Commercial Security Systems	7.5	11,214
Commercial Monitors	7.5	70,746
Elevators	5.7	751
Medical Imaging Equipment	4.9	478
Commercial Televisions	3.9	19,194
Commercial Video Displays	3.6	9,028
POS Systems	1.6	5,430
Commercial Laptop PCs	0.8	30,358
Warehouse Robots	0.02	20

** Installed base units in million gallons per year (Mgal/yr) for wastewater treatment and water supply & purification*

Computing energy consumption
AEO2023 and AEO2025 Reference case
trillion British thermal units

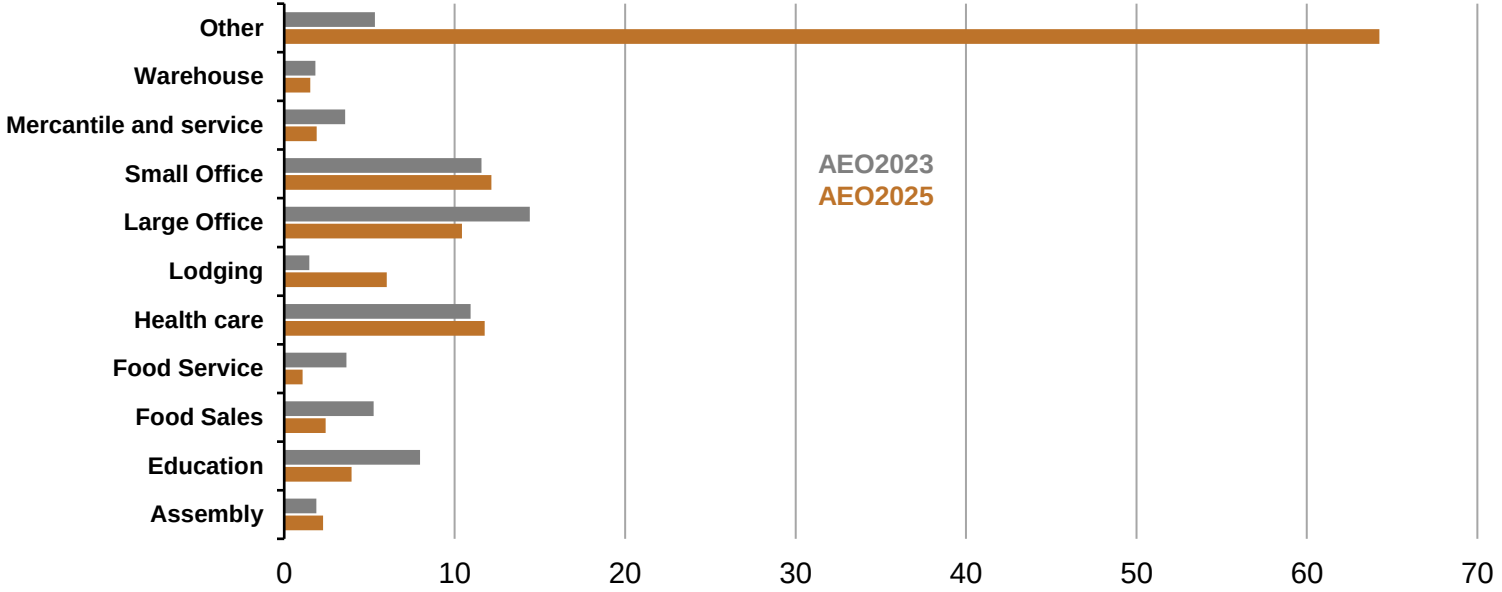


Data sources: Guidehouse, Inc. and Leidos, Inc., prepared for the U.S. Energy Information Administration (2021); U.S. Energy Information Administration Annual Energy Outlook 2025 Reference case preliminary

To the extent that standalone data centers are represented in the latest CBECS, they are modeled in the "Other" NEMS building type

Average intensity of computing electricity use, by NEMS building type, 2050

thousand British thermal unit per square foot, AEO2023 reference case and AEO2025 preliminary reference case



Data source: U.S. Energy Information Administration, AEO2023 Reference case and AEO2025 preliminary reference case

Assumptions about energy efficiency incentives affect end-use energy projections

Select rebates as a percentage of installed cost by residential end use
percent, AEO2025 Preliminary reference case

Technology	New England	Middle Atlantic	East North Central	West North Central	South Atlantic	East South Central	West South Central	Mountain	Pacific
Ground-Source Heat Pumps	24.8%	10.2%	8.1%	6.4%	7.0%	8.8%	3.7%	5.0%	2.5%
Air-Source Heat Pumps	14.4%	5.2%	7.9%	4.8%	2.2%	0.0%	19.4%	4.6%	11.1%
Clothes washers (front)	7.9%	3.0%	3.0%	1.5%	2.7%	3.4%	4.4%	3.6%	7.1%
Refrigerators (top-mounted freezer)	1.1%	5.1%	4.5%	2.8%	5.7%	8.3%	0.9%	3.8%	10.9%
Electric heat pump water heaters	26.0%	25.6%	14.9%	11.7%	13.2%	6.7%	20.5%	8.6%	22.6%

Note: Installed equipment costs to which these rebate assumptions are applied are available on eia.gov in our *Updated Buildings Sector Appliance and Equipment Costs and Efficiency* reports by Guidehouse and Leidos, prepared for the U.S. Energy Information Administration (2023).

Data sources: U.S. Energy Information Administration (EIA), Annual Energy Outlook 2025 Preliminary Reference case, Northeast Energy Efficiency Partnerships, Northeast Regional Energy Efficiency Database (REED) 2021 data update, Program and Measure Data: Report on Results of Investigations, May 2020; ENERGY STAR Summaries of programs, 2022; Consortium for Energy Efficiency Program Summaries, 2023 and 2024 all normalized to report dollar years, 2022.

Improving technology representation in NEMS beyond AEO2025

- Behind-the-meter battery energy storage
- Update and regionalize residential major end-use equipment fuel and technology switching costs
- Model thermal storage technologies: standalone, equipment-integrated, and envelope-integrated**
- Revise building envelope heating and cooling loads, residential new construction costs, and residential weatherization effects**
- Investigate effects of hydrogen blending on end-use equipment

***Depends on funding and data availability*

For more buildings information

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For more information

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

Annual Energy Outlook 2025 Resources | www.eia.gov/outlooks/aeo/resources

Annual Energy Outlook Working Group materials | www.eia.gov/outlooks/aeo/workinggroup

Today in Energy | www.eia.gov/todayinenergy

Annual Energy Outlook | www.eia.gov/aeo

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

State Energy Data System | www.eia.gov/state/seds

Monthly Energy Review | www.eia.gov/mer

Residential Energy Consumption Survey | www.eia.gov/recs

Commercial Buildings Energy Consumption Survey | www.eia.gov/cbecs

International Energy Portal | www.eia.gov/international

Questions or comments?

Bonus slides

Buildings energy data and modeling resources

Use our data, reports, and studies

- 2020 Residential Energy Consumption Survey (RECS)
- 2018 Commercial Buildings Energy Consumption Survey (CBECS)
- Repository of buildings reports and studies

Learn about our assumptions

- Documentation of the National Energy Modeling System (NEMS) Modules
- Assumptions to the *Annual Energy Outlook 2023*
- Updated Buildings Sector Appliance and Equipment Costs and Efficiency
- Analysis and Representation of Miscellaneous Electric Loads (MELs) in NEMS
- Distributed Generation System Characteristics and Costs in the Buildings Sector
- Modeling Distributed Generation in the Buildings Sectors
- Trends in Commercial Whole-Building Sensors and Controls
- Price Elasticities for Energy Use in Buildings of the United States

Contact our staff

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Source: https://www.eia.gov/consumption/workshop/resources.php