

Modeling the Effects of Electrification in Buildings Using the National Energy Modeling System

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ABSTRACT

According to the U.S. Energy Information Administration's (EIA) *Annual Energy Outlook 2022* (AEO2022), residential and commercial buildings account for about a third of energy-related carbon dioxide emissions in the United States (EIA 2022).¹ To help address climate change, state and local governments across the country are increasingly focusing on the role of electrification and decarbonization in the residential and commercial buildings sectors. But what do building electrification and decarbonization mean? What is driving change? What effects will these changes have both on buildings and utilities, and who will pay to implement them? Policymakers and analysts often rely on detailed energy models to estimate the long-term impacts of such transformative shifts in energy use.

In this paper, we discuss how EIA's National Energy Modeling System (NEMS) can be used to project ways in which technology, policy, behavior, and economic changes may drive the future of electrification in buildings. We assess NEMS's current capabilities and possible future model improvements. NEMS is distinguished from many other models in that it is an integrated U.S. energy sector model, which enables users to analyze how changes within the buildings sector can affect energy markets as a whole (EIA 2019).

The authors review historical data from the U.S. Census Bureau, as well as EIA's *Commercial Building Energy Consumption Survey* and *Residential Energy Consumption Survey*, to identify recent regional electrification trends in buildings. We discuss what electrification represents for buildings sector fuel switching and energy efficiency. We also discuss future considerations about modeling energy storage, geographic data limitations, and opportunities for the future development of NEMS.

Introduction

Commercial and residential buildings combined account for a third of U.S. end-use sector carbon dioxide (CO₂) emissions (Figure 1). In the *Annual Energy Outlook 2022* (AEO2022) Reference case, this share is projected to decline slightly over time. To help address climate change, the federal, state, and local governments across the country are increasingly focusing on the role of electrification and decarbonization of the residential and commercial buildings sectors. Concurrent efforts are underway to address decarbonization of transportation, industrial, and power sectors.

¹ Estimated share includes emissions associated with power generation, transmission, and distribution that meets buildings demand for electricity.

Energy-related carbon dioxide (CO₂) emissions by sector
AEO2022 Reference case, million metric tons CO₂

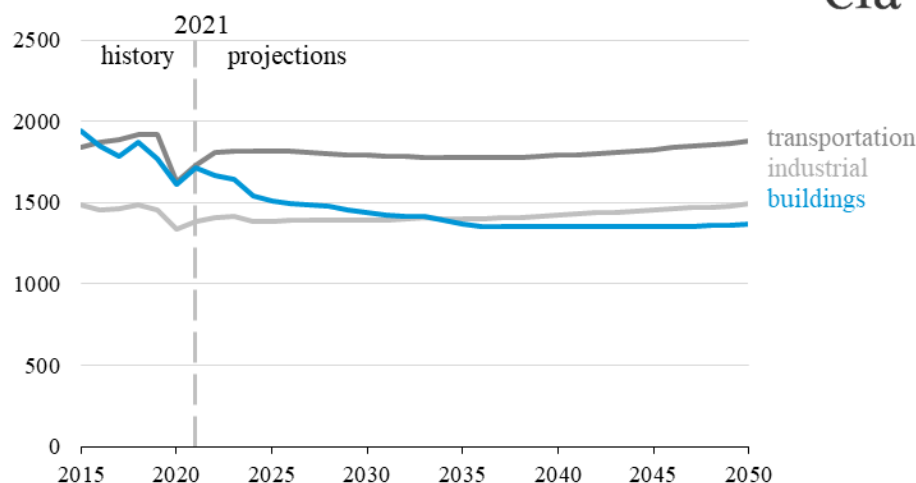


Figure 1. Carbon dioxide emissions (million metric tons CO₂). *Source:* EIA 2022. Figure includes emissions associated with electric power generation. Electric power sector emissions are distributed to each end-use sector according to the sector's share of electricity consumption.

The concept of building electrification is not a new one. The first electric arc lamps developed in the early 19th century were designed to replace candles as well as oil and gas lamps (DOE 2013). Through the late 19th century, the establishment of alternating versus direct current in the War of the Currents featuring Nikola Tesla, George Westinghouse, and Thomas Edison led to expansion of electricity access in major cities across the United States (DOE 2014). In 1926, the Alabama Power Company personified electricity as the Reddy Kilowatt cartoon character promoting rural electricity use (Kazek 2016), while the Rural Electrification Act of 1936 provided low-cost loans for electrifying farms (NPS 2021). Later, the Live Better Electrically marketing campaign led by utilities and electric manufacturers in the mid-1950s continued to encourage the use of electricity over other fuels in homes (DAHPP 2022).

Electrification efforts focus on expanding the use of electric equipment in place of other technologies that use natural gas, propane, or distillate fuel oil. Modern programs encouraging electrification for decarbonization may focus on electrifying space heating, water heating, cooking, and clothes drying equipment. Even landscaping equipment such as lawnmowers and string trimmers now have electric alternatives. Of course, electrification can refer to more than fuel switching; in some instances, formerly non-electric items—such as toothbrushes—are becoming increasingly electrified.

The U.S. energy market can be characterized as a web of interactions between energy consumers and producers. EIA collects, analyzes, and disseminates independent and impartial energy information to promote sound policymaking, efficient markets, and public understanding of energy and its interaction with the economy and the environment. To achieve these goals, EIA has developed a comprehensive energy projection model: the National Energy Modeling System (NEMS). EIA publishes NEMS modeling results in the AEO and presents analyses about how the U.S. energy market responds to policies and market conditions.

In this paper, we will demonstrate how energy modelers can use NEMS to better understand different pathways that lead to further electrification and decarbonization in U.S.

buildings. This paper will briefly explain NEMS, discuss results from AEO2022 and findings from various historical data sources, and describe the technology, policy, behavior, and economic assumptions analysts can augment or change to model decarbonization and electrification scenarios.

National Energy Modeling System

NEMS is an integrated model that captures interactions of economic changes and energy supply, demand, and prices. It relies on historical consumption as well as market data and estimates changes to the various domestic energy markets over the next 30 years.

NEMS projections are not predictions of what will happen, but rather, they are modeled projections of what may happen given certain assumptions and methodologies. The NEMS ecosystem includes different modules focusing on energy supply, conversion, and demand. This report focuses on commercial and residential buildings within the end-use demand sectors modeled in NEMS (Figure 2).

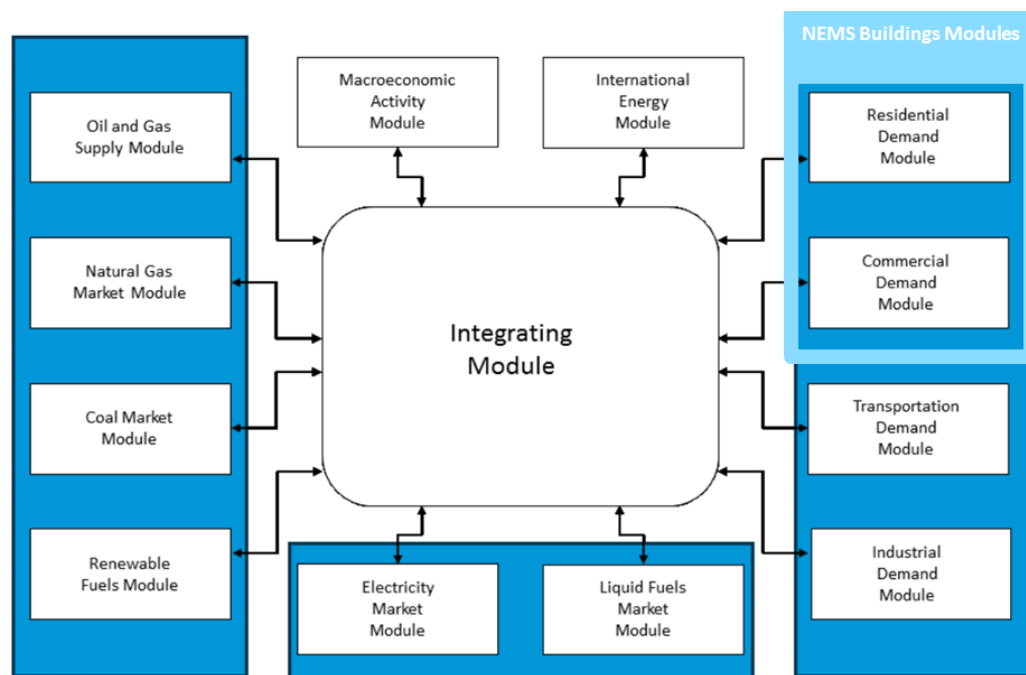


Figure 2. NEMS conceptual layout. *Source:* EIA 2019.

As seen in detailed model documentation, the NEMS Commercial Demand Module (CDM) and Residential Demand Module (RDM) project annual energy consumption by fuel and end use at the U.S. census division level (EIA 2022a). These modules allow users to make different assumptions that affect electric equipment choices and use (EIA 2022b).

Each year, EIA uses a version of NEMS to produce the AEO. EIA provides NEMS source code, input files, detailed output files, assumptions, and associated documentation to the general public via its website; however, NEMS operation requires access to software packages that must be purchased from third-party vendors. The following discussion of the NEMS CDM and RDM is based on the archived version of NEMS that EIA used to produce AEO2022 (EIA 2022c).

NEMS has not been tested under all possible technology, policy, behavior, and economic scenarios, so modelers and users of NEMS must be cautious in how assumptions are applied. The further the model is pushed, the more model outputs and debug files should be examined in order to ensure that results are reasonable and as-expected. Certain changes to the inputs and assumptions mentioned below may necessitate modifications of source code, model parameters, or other inputs not explicitly discussed in this report. For further information, refer to the detailed module documentation, source code, and information provided within NEMS input files.

Numerous tools are available to model electrification and decarbonization in U.S. buildings. Because NEMS is an integrated U.S. energy sector model, modelers can use it to analyze how changes within the buildings sector can affect energy markets as a whole. Table 1 contains specific modeling elements and associated assumptions that affect rates of electrification in NEMS. These modeling elements pertain to NEMS's representation of four broad categories of assumptions: available technologies, related policies, consumer behavior, and economic drivers for energy use. Specific NEMS input files associated with each assumption and modeling element are listed in the Appendix. Modelers within and external to EIA can and do use EIA's annual Reference case results as a baseline to understand how changing these modeling elements could affect the buildings sector and energy markets more broadly.

Table 1. NEMS assumptions and modeling elements that directly affect buildings electrification

Category	Model assumptions	NEMS modeling elements
Technology	Improved efficiency	Technology characteristics Miscellaneous electric loads (MELs) characteristics Distributed generation (DG) and combined-heat-and-power (CHP) characteristics Building envelope characteristics
	Reduced equipment or installation costs	Technology, DG/CHP characteristics
	New technology options	Technology, MELs, DG/CHP characteristics
	Fuel switching	Technology characteristics
Policy	Future energy efficiency standards	Technology, MELs, DG/CHP characteristics
	Building energy codes	Building envelope characteristics
	Utility energy efficiency rebates	Technology, DG/CHP characteristics
	Federal tax credits	Technology, DG/CHP, building envelope characteristics
Behavior	Consumer purchase behavior	Decision parameters
	Consumer preferences for upfront versus operating costs	Decision parameters
	Responses to increasing fuel prices	Price elasticities

Category	Model assumptions	NEMS modeling elements
Economic	Varying rates of sector growth (residential households or commercial floorspace)	NEMS Macroeconomic Activity Module outputs
	Population growth	
	Disposable income	
	Interest rates	
	Discount rates	

Source: EIA 2022a.

Technology changes may come from increased research and development, which can yield cheaper or more-efficient equipment, or from new technologies coming to market. In the case of space heating and water heating, electric heat pumps may replace fossil-fuel burning equipment or electric resistance equipment, although the costs associated with switching fuels or equipment type must be considered.

Various policies can affect levels of electrification in buildings. These policies may include future energy efficiency standards that increase the minimum performance of replacement equipment, or they can include building energy codes that can reduce space heating and cooling loads. Incentives and subsidies that reduce the purchase or installation costs of equipment can also increase adoption of specific types of equipment.

The representation of consumer behavior plays a major role in NEMS's ability to model the effects of electrification in buildings. Varying shares of consumers may choose to use the same type of equipment, or same fuel, as previously installed. The decision to replace or retrofit equipment can also depend on consumer preference for incurring upfront versus operating costs, as well as sensitivity to changes in fuel prices.

In addition to the AEO2022 Reference case, Low and High Economic Growth cases show how alternative economic drivers from the NEMS Macroeconomic Activity Module can affect the buildings sector as a whole (EIA 2022d).

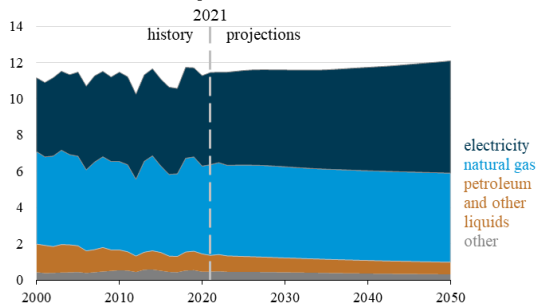
Historical building electrification trends

Before we can model electrification, we develop a Reference case based on current laws and regulations (EIA 2022e). Comparing this Reference case with alternative cases, including those with alternative electrification assumptions, can provide useful information about the effects technology, policy, consumer behavior, and the overall economy can have on fuel consumption, end-use technology shares, and regional differences. Below is a description of AEO2022 Reference case results.

Fuel consumption

In the AEO2022 Reference case, electricity accounted for 42% of residential energy consumption and 50% of commercial energy consumption in 2021 (Figure 3, EIA 2022f). Efforts to increase electrification in the buildings sector target fossil fuels such as distillate fuel oil, propane, and natural gas.

Residential sector delivered energy consumption by fuel
AEO2022 Reference case, quadrillion British thermal units



Commercial sector delivered energy consumption by fuel
AEO2022 Reference case, quadrillion British thermal units

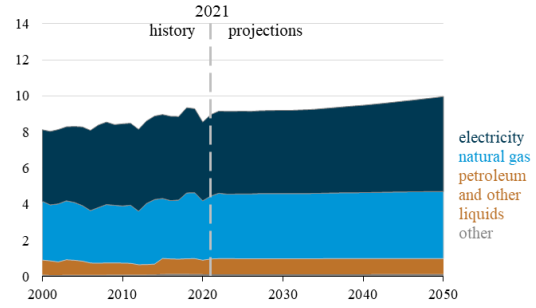


Figure 3. Commercial and residential sector delivered energy consumption by fuel (quadrillion British thermal units). *Source: EIA 2022f.*

End-use technology shares

Electrification can apply to a number of end uses within buildings, including space heating, water heating, cooking, and clothes drying. Looking at past iterations of EIA's *Residential Energy Consumption Survey* (RECS) and *Commercial Buildings Energy Consumption Survey* (CBECS), we can see that fossil fuels continue to be the primary space heating fuels in buildings. According to the 2015 RECS, air- and ground-source heat pumps were used in 10% of existing residential households (Figure 4, EIAg). In the 2012 CBECS, electric space heating equipment was used in 30% of commercial floorspace (Figure 4, EIAh). The 2015 RECS and 2012 CBECS provided base-year characterizations of the buildings sector. These historical characterizations serve as the starting point for end use-level buildings projections in AEO2022.

Share of households by primary space-heating type
Residential Energy Consumption Survey, percent

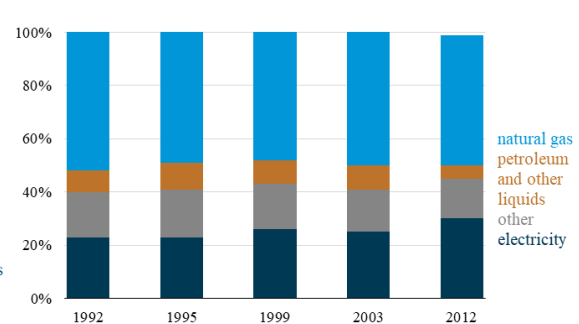
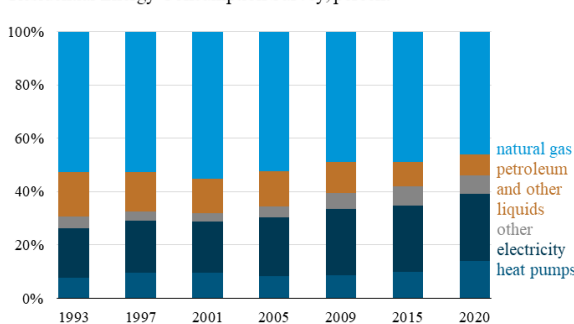


Figure 4. Share of commercial floorspace and residential households by primary space-heating type (percentage). *Sources: EIA 2022g and EIA 2022h.*

Regional considerations

Current rates of electrification of space heating can vary from region to region, in part due to varying fuel prices and space heating and space cooling loads. Additional information regarding the effects of regional heating and cooling trends on end-use consumption is available in the AEO2022 *Alternative Weather Assumptions Issues in Focus* report (EIA 2022i).

According to the U.S. Census Bureau's Survey of Construction, 44% of new single-family homes in the United States were built with electric primary space heating equipment in 2020 (Figure 5). The South shows a greater share of heat pumps, while the Northeast has the greatest shares of distillate fuel oil equipment. U.S. heat pump adoption in new homes increased to 34% as a share of heating equipment installed in single-family construction (U.S. Census Bureau, 2021).

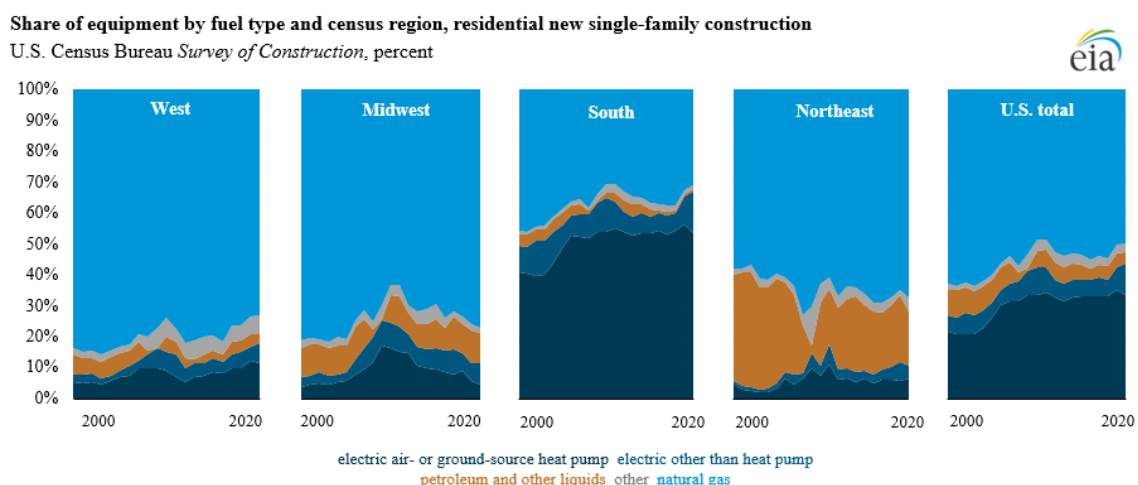


Figure 5. Share of residential space heating equipment by fuel type and census region, residential new single-family construction, percent. *Source:* U.S. Census Bureau 2021.

Because the NEMS RDM uses a stock turnover model, we are able to benchmark new (post-RECS-year) space heating equipment shares to historical Survey of Construction data.

Modifying electrification-related assumptions in NEMS

Further electrification and decarbonization of buildings can take many theoretical pathways. Generally, we can think of key determinants of potential energy consumption and efficiency change over time in four broad categories: technology, policy, consumer behavior, and economic drivers.

Technology

Equipment efficiency and equipment costs

No discussion about electrification is complete without exploring the effects of energy efficiency. More-efficient equipment reduces demand for fuel to provide end-use services such as space heating and water heating. Equipment that burns fuel to generate heat has thermal losses associated with combustion, while heat pumps move heat from areas of higher concentration to lower concentration. As a result, heat pump efficiency can exceed 100%. Electric resistance heating, commonly used as a backup or emergency heat source for heat pumps at lower ambient temperatures, is assumed to convert 100% of electricity consumed into heat.

NEMS commercial and residential technology menu inputs are used to characterize major end-use equipment performance and costs in model projection years. EIA uses contractor report data to populate these menus. Future improvements to equipment efficiency driven by increased research and development funding, for instance, can be reflected in these inputs as either

increases in equipment efficiency or lower production costs that are passed on to consumers as reduced equipment costs. Alternatively, improved installation proficiency can result in lower installed equipment costs (for example, more effective ground-source heat pump well drilling).

Miscellaneous electric loads (MELs) are modeled in less detail than major end uses such as space heating, water heating, and clothes drying. In general, EIA attempts to characterize equipment and devices that are covered by federal minimum energy efficiency standards and ENERGY STAR specifications. Modelers are able to adjust projected changes to average annual energy consumption or national device stocks (residential) driven by efficiency improvements. Equipment costs that may be associated with changes in efficiency are not considered when modeling MELs.

New technologies

EIA's modeling of equipment and devices in NEMS can be thought of as evolutionary rather than revolutionary. Technologies that exist now are generally expected to become more efficient and less expensive over time. Obvious exceptions to this concept include incandescent and fluorescent lighting technologies that have been phasing out—for various technological and policy reasons—with growing adoption of LED lighting.

Modelers can use the CDM and RDM technology menus to introduce revolutionary technologies associated with electrification, or those under development but not commercially available, as long as the efficiency and performance metrics used for those technologies are comparable to existing technologies with which they would compete for consumer purchase. For example, an electric cooking range with an induction cooktop can be 5%–10% more efficient than conventional electric resistance coils, so an electric cooking range could be modeled as having 5%–10% less annual energy consumption in kilowatthours. The same concept holds true for heat pump or ultrasonic clothes dryer technologies.

Modelers can include new equipment *classes* for residential technologies, adding corresponding equipment characteristics to the technology menu and shell packages (if modeling space heating or cooling equipment). If new equipment classes are added, further changes to the residential code, as well as base-year equipment stocks, unit energy consumption, efficiency, and other relevant input and parameter files are required.

In addition to manually reducing equipment costs, the NEMS CDM and RDM use endogenous cost learning within their respective technology menus. These cost trend functions differentiate between mature, adolescent, and infant technologies and adjust equipment costs over time and with adoption. For distributed generation technologies such as solar photovoltaics, global technology learning across commercial, residential, and utility-scale systems allows for reduced equipment costs as more capacity is adopted.

Similar to adding new equipment classes, when users add new commercial or residential MELs, they must ensure consistency within the CDM and RDM structure and for NEMS as a whole. When users add new technologies to NEMS, they must review the corresponding sections of the CDM and RDM to ensure that new inputs are being read in and used to calculate consumption appropriately, and that consumption is output or aggregated with other end uses as necessary.

Fuel switching

In addition to equipment costs, switching from fossil fuel-burning to electric equipment may inherently necessitate other upgrades within buildings. Incremental costs associated with fuel switching may include additional wiring or service panel upgrades, refrigerant line

plumbing, or duct installation. In addition, existing natural gas, propane, or distillate fuel oil infrastructure may need to be removed or abandoned (for example, natural gas lines, tanks, and chimneys).

The RDM includes costs associated with switching between different space heating, cooling, water heating, cooking, and clothes drying fuels and technologies. The CDM does not include explicit assumptions assuming specific equipment pairings, relying instead on CBECS for shares of service demand met by specific equipment and fuels.

Policy

Efficiency standards

In the AEO Reference case version of NEMS, EIA assumes that current laws and regulations that affect buildings, including laws that have end dates, remain unchanged throughout the projection period. We do not assume future iterations of federal minimum energy efficiency standards because the timeline and extent to which standards change can vary.

In NEMS commercial and residential technology menus, the ultimate effect of federal minimum energy efficiency standards is that, beginning in a specific year, equipment that does not meet the standard is no longer chosen by the model. The technology menu options include vintages of equipment that are available for consumer choice during specific years. For instance, if a new federal minimum efficiency standard required all water heaters to use heat pump technology beginning in a specific year, any vintages of electric resistance water heaters would be modified to cease in the year before the standard goes into effect. NEMS operates in calendar years, so any new standard is assumed to be effective on the first day of the year.

Making alternative assumptions for revised or future standards requires adding equipment vintages to the technology menus, where users can incorporate expected performance and cost changes implied by a new standard.

Because the residential building shell package menu is closely tied to space heating and cooling technology choice, additional vintages corresponding to the new standard must be inserted across package types. No commercial corollary exists.

Rebates and tax credits

Within NEMS, incentives provided by non-federal (for example, utility-sponsored) energy efficiency programs operate similarly to those provided by federal tax credits for major end-use equipment in that they are assumed to reduce the installed cost of new, energy-efficient equipment. NEMS commercial and residential technology menus allow for non-federal rebates at the census division level as well as federal tax credits. The commercial and residential technology menus summarize energy efficiency rebate information, tax credits, and subsidy calculations. Users can modify these values, and calculations within the technology menus will reflect those changes.

Building energy codes

As with federal minimum energy efficiency standards, EIA does not assume any specific future building energy code adoption. No single national building code exists, and other codes can vary by state and municipality.

Some jurisdictions across the country may limit new natural gas connections through building energy codes or moratoria. Others may adopt newer model energy codes (for example, the International Energy Conservation Code, or IECC) that require buildings to be gas- and

electric-ready for particular end use-equipment. In NEMS, these energy codes are implemented through eliminating future options of residential shell packages in the building shell characteristics menu, although such changes would be assumed to occur at the census division level. In the commercial technology menu, equipment vintages can be used to identify a future year in which specific equipment types are no longer permissible.

A NEMS user can force in (or out) shares of new equipment of a specific fuel or type to answer questions like “What could electricity consumption look like in a specific census division if all new residential equipment were electric air-source heat pumps?” The user could set all census division shares of air-source heat pumps to 100%, and eliminate all other space heating equipment options.

Behavior

Purchasing decisions

NEMS accounts for various consumer purchasing decisions and preferences. The commercial behavior input file characterizes the share of commercial consumers choosing to purchase equipment based on least cost, same fuel type, or same technology type for new, replacement, and retrofit decisions. Occupancy type (that is, renter- or owner-occupied) contributes to the type of equipment that is chosen by the CDM. Most buildings are currently assumed to choose the same fuel or same technology for space heating, water heating, and cooking end uses, so different assumptions are needed to model behavior differences due to electrification.

The RDM incorporates assumptions pertaining to fuel and equipment choices in residential new construction. Shell packages represent possible mixes of space heating and cooling equipment, and relationships between the equipment classes assume, for example, that a new home with natural gas space heating is likely to have natural gas water heating and cooking equipment.

In addition to calculated lifecycle costs and fuel switching costs, behavior parameters in RDM inputs are used to compute replacement shares for each equipment class in single-family homes. A separate switching factor is used to limit the maximum fraction of single-family homes that may switch away from each specified equipment class upon replacement.

Capital, operating, and lifecycle costs

CDM inputs characterize assumptions for commercial consumers’ preference valuing capital costs versus fuel and operating costs. The model uses a discrete distribution of consumer risk-adjusted time preference premiums to calculate effective hurdle rates and characterize the commercial consumer decision-making population.

Behavior parameters in RDM inputs represent consumer consideration for capital costs versus operating costs when choosing which equipment to purchase. The ratio of these parameters form an implicit discount rate for each residential technology. For instance, these calculations may determine if consumers are more likely to purchase cheaper equipment that meet federal minimum energy efficiency standards or more-efficient equipment that is ENERGY STAR qualified. In addition, the RDM includes explicit discount rate and tenure (average time spent in a home) parameters that are used in lifecycle costs.

Fuel price elasticity

NEMS uses elasticities to account for consumer response to changes in fuel prices. This approach is different than the rebound effect, which assumes some increase in consumption associated with efficiency improvements. The CDM characterizes commercial short-run price elasticity, or the amount of change in service demand, as the result of changes in energy prices for electricity, natural gas, and distillate fuel oil. Residential short-term price elasticity assumptions are characterized for different end uses modeled in the RDM.

Economic

Sector growth

Many economic drivers that affect the buildings sector are delivered endogenously within NEMS from the Macroeconomic Activity Module (MAM) and so are not controlled by the CDM or RDM. The amount of new commercial floorspace added and the number of new homes built each year drive overall buildings sector growth and ultimately determine the number or types of new equipment—and therefore contribute to overall stock efficiency—for different end uses.

Differing building stock assumptions or changes in population, as well as varying interest rates or levels of disposable income, can play a role in buildings energy use. Projected residential air-source and ground-source heat pump stocks, for instance, deviate most from the Reference case in the Low Economic Growth and High Economic Growth cases (Figure 6).

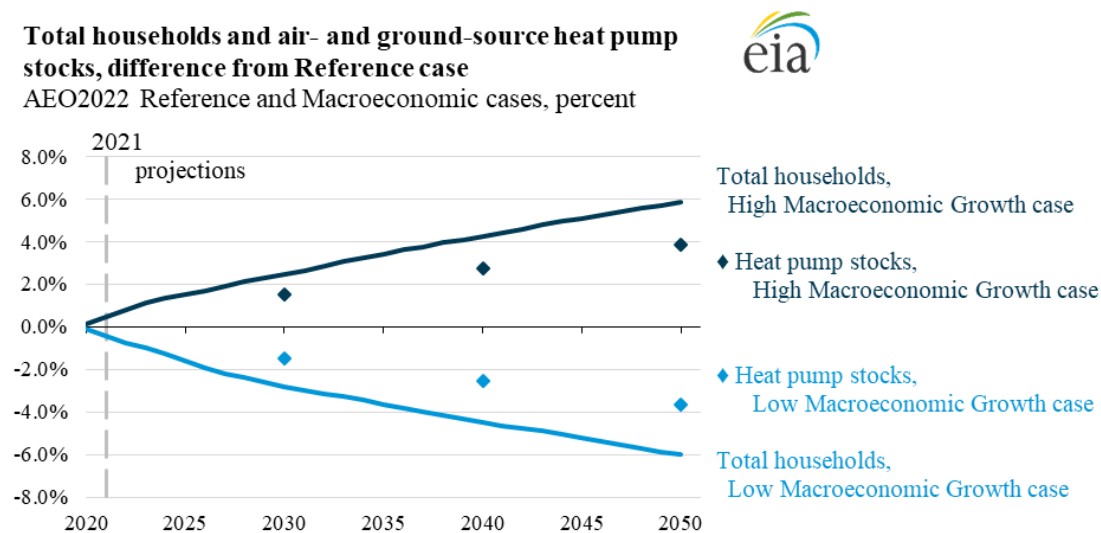


Figure 6. Stock of air- and ground-source heat pumps and total households (percentage difference from Reference case results). *Source:* EIA 2022.

Population growth

Where and how the population grows may determine where and what types of new buildings are constructed. It may also determine how energy is used within buildings in different parts of the country. Population-weighted heating and cooling degree days used by the CDM and RDM currently account for migration of population around the country, typically from warming-dominated to cooling-dominated areas. Population is also divided by number of households in each census division to estimate how the average number of occupants per housing unit affects water heating demand.

Disposable income

Real personal disposable income is used in calculations for select residential MELs. Modelers can use changes in personal disposable income as an additional driver for residential consumption by device type. For AEO2022, devices categorized as MELs that are explicitly modeled in NEMS include smartphones, tablets, video game consoles, and more (EIA 2021). Disposable income is used to grow consumption of uncharacterized residential electricity consumption not attributed to any specific end use.

Disposable income is also considered when estimating residential solar photovoltaic adoption. A separate report discusses our modeling of distributed generation technologies in further detail (EIA 2020).

Interest rates

The NEMS Macroeconomic Activity Module generates real average yields on U.S. Treasury long-term (10-year) bonds, which factors into the commercial behavioral parameters discussed previously. These real average yields are also used to calculate annualized technology capital costs payments over the life of commercial equipment.

Future Considerations

Space heating consumes more energy than any other single end use in the buildings sector. The prospect of growth in heating electrification is an active area of research for EIA. Regional data availability presents the greatest challenge to projecting the effects of electrification in buildings, especially because regional weather and construction characteristics significantly affect building space heating loads. EIA's primary data sources for characterizing the commercial and residential sectors—CBECS and RECS—have historically featured statistically significant data at the census division level. Cost and complexity related to larger survey samples limit EIA's ability to release more granular data, although recent changes in survey methodology mean that the 2020 RECS will be able to publish select state-level data.

Even with more granular base-year data for the CDM and RDM, other modules of NEMS that interact with the commercial and residential modules may be similarly constrained by the regionality of data available for input or output. EIA would likely require supplementary state-level data to accommodate any increased modeling granularity, and EIA's survey respondents must remain anonymous with any changes to NEMS data granularity.

As of AEO2022, the NEMS CDM and RDM are not capable of modeling distributed battery storage systems. Increased use of variable renewable energy in deep decarbonization scenarios inherently requires the ability to model such storage systems. EIA has collected initial cost and performance characteristic data for commercial- and residential-scale systems, although rapid developments affecting lithium batteries will likely continue to drive costs downward. Furthermore, incorporation of distributed battery energy storage modeling into NEMS could benefit from cross-sector interactions. Cost learning between buildings, transportation (for example, battery and plug-in hybrid electric vehicles), and utility sectors would reflect the potential effects of any comparable chemistries, resources, and manufacturing practices.

Increasing use of electric equipment and appliances unlocks potential for different utility programs such as demand response and direct load control, although neither are currently captured in NEMS.

States and jurisdictions across the country are increasingly using Property Assessed Clean Energy (PACE) financing to increase the adoption of energy efficiency and electrification.

Such financing methods are not currently modeled in NEMS. Although commercial PACE programs are more prevalent, residential programs also exist. NEMS also does not currently account for on-bill utility financing for energy efficiency retrofits.

Deep decarbonization efforts will likely include growing adoption of net-zero energy, net-zero carbon, or grid-interactive efficient buildings that are not explicitly modeled in NEMS. EIA will continue to explore adding such capabilities, as well as many of those listed previously, in the ongoing development of NEMS.

Conclusion

NEMS can project the potential for wider buildings electrification in the United States based on changes in technology, existing policies or assumptions about future policies, the effects of technological advancement, consumer behavior in the residential and commercial sectors, and dynamics in the broader economy. NEMS modelers regularly respond to requests for information about equipment stocks across the United States, assumptions about technology efficiencies and costs, the prevalence of distributed generation, macroeconomic and climatic conditions observed in history and NEMS projections concerning the same, and more.

EIA's mandate and mission is to provide independent, policy-neutral data and analysis about the U.S. energy system. NEMS is available to the public on eia.gov so others can verify model results and input their own assumptions about interactions between energy use, policy developments, and the economy. As electrification policies, technologies, consumer behavior, and the economy change, NEMS can account for these developments, and the AEO will include a discussion of these changes in our annual assumptions and documentation.

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Appendix

NEMS modeling elements and input files that directly affect buildings electrification

Category	NEMS modeling elements	NEMS buildings input files
Technology	Technology characteristics	ktekx.xlsx, comparm, rsmess-rsmeqp, rsstk, rseff, rsmess-rsclass, rsswitch
	Miscellaneous electric loads (MELs) characteristics	kmels, comparm, rsmels, rsstk, rseff
	Distributed generation (DG) and combined heat-and-power (CHP) characteristics	kgentk, rsgentk
	Building envelope characteristics	comm.f, ksheff, resd.f, rsmess-rsmshl
Policy	Technology characteristics	ktekx.xlsx, rsmess-rsmeqp, rsmshl
	MELs characteristics	kmels, rsmels
	DG and CHP characteristics	kgentk, rsgentk
	Building envelope characteristics	comm.f, ksheff, resd.f, rsmshl, rsmess-rsmshl
Behavior	Consumer purchase behavior	kbehav, rsmess-rsclass
	Consumer preferences for upfront versus operating costs	rsmess-rsmeqp, kprem
	Responses to increasing fuel prices	comm.f, ksdela, resd.f, rsmisc
Economic	NEMS Macroeconomic Activity Module and consumer behaviors	kprem, rsmisc

Source: EIA 2022a.