EFFICIENT NEW HOMES WITH FEDERAL SUPPORT WILL SAVE MONEY, CREATE JOBS, AND CUT EMISSIONS

Lowell Ungar and Aimee Bell-Pasht

May 2022
White Paper

Smart Energy. Clean Planet. Better Lives.

Contents

About ACEEE

The **American Council for an Energy-Efficient Economy** (ACEEE), a nonprofit research organization, develops policies to reduce energy waste and combat climate change. Its independent analysis advances investments, programs, and behaviors that use energy more effectively and help build an equitable clean energy future.

About the Authors

Lowell Ungar is the director of federal policy at ACEEE. He develops and promotes legislation and administrative actions in all economic sectors and leads crosscutting policy research. Prior to joining ACEEE, Lowell was director of policy at the Alliance to Save Energy and a legislative aide in both the U.S. Senate and the House of Representatives. Lowell earned a PhD in physical chemistry from the University of Chicago and a bachelor of science in chemistry from Stanford University.

Aimee Bell-Pasht is a senior research associate in ACEEE's federal policy program. Before joining ACEEE, Aimee worked as an economist at the Massachusetts Department of Public Utilities supporting regulatory oversight of gas and electric utilities on a range of issues, including utility-run energy efficiency programs, geothermal district heating pilot programs, and retail energy consumer protections. Aimee earned a master's degree in applied economics from the University of Massachusetts Boston and a bachelor's degree in economics from McGill University.

Acknowledgments

This report was made possible through the generous support of the Tilia Fund and the North American Insulation Manufacturers Association. The authors gratefully acknowledge external reviewers, internal reviewers, colleagues, and sponsors who supported this report. Ariel Drehobl and Jim Barrett contributed to the research in this report. The authors also gratefully acknowledge the assistance of Michael Freedberg and Lauren Ross from the U.S. Department of Housing and Urban Development, Michael Rosenberg and Robert Salcido from the Pacific Northwest National Laboratory, and Dean Gamble and Rebecca Hudson from the U.S. Environmental Protection Agency. Additional external expert reviewers included Ryan Colker from the International Code Council, Charlie Haack from the North American Insulation Manufacturers Association, Mark Kresowik from RMI, and Lauren Urbanek from NRDC. Internal reviewers included Steve Nadel and Lyla Fadali. External review and support do not imply affiliation or endorsement. Last, we would like to thank Mary Robert Carter for managing the editorial process, Mariel Wolfson for developmental editing, Elise Marton for copy editing, Roxanna Usher for proofreading, and Ben Somberg, Nick Roper, and Wendy Koch for their help in launching this report.

Suggested Citation

Ungar, L., and A. Bell-Pasht. 2022. *Efficient New Homes with Federal Support Will Save Money, Create Jobs, and Cut Emissions*. Washington, DC: American Council for an Energy-Efficient Economy. www.aceee.org/white-paper/2022/05/efficient-new-homes-federal-support.

Executive Summary

KEY TAKEAWAYS

Requiring that new homes receiving federal support meet the latest model building energy codes could:

- Yield $5,700 in lifetime net savings for the average household and $27 billion in total net savings (present value)
- Create 838,000 jobs (net added job-years)
- Avoid 275 million tons of CO_2 emissions, equivalent to the carbon from 59 million cars and light trucks for a year
- Slightly reduce the number of households with high housing cost burdens

Requiring that homes meet new ENERGY STAR® efficiency levels would almost double the savings.

The cheapest and easiest time to avoid energy waste in a home is when the home is built. Building energy codes for new homes are set at the state or local level and vary widely. However, the federal government sets national efficiency criteria for many of the new and rehabilitated homes for which it provides financial support. These homes are primarily for low- and moderate-income homeowners and renters. Setting up-to-date energy efficiency requirements for these homes would improve home quality, reduce monthly costs, lessen vulnerability to fuel price spikes, boost the health and comfort of residents, and ensure long-term reductions in greenhouse gas emissions.

New homes purchased with federally backed loans such as Federal Housing Administration (FHA) mortgages, along with new homes with funding from federal programs like the HOME Investment Partnerships grants for affordable housing, make up about one-fifth of all new single-family residences and one-eighth of new units in multifamily buildings. But the efficiency requirements for these homes are badly out of date. And some homes with federal support have no efficiency requirements at all. Most notably, Fannie Mae and Freddie Mac, government-sponsored enterprises (GSEs) under the supervision of the Federal Housing Finance Agency, buy almost half of all mortgages for single-family home purchases and multifamily buildings but have not set efficiency requirements for those homes.

ANALYSIS OF IMPACTS

We analyzed the economic and environmental impacts of strong efficiency requirements for new homes that receive federal support. The analysis used Pacific Northwest National Laboratory building modeling and projections from the Energy Information Association's Annual Energy Outlook 2022. We first looked at upgrading homes from current baseline efficiency to meet the 2021 International Energy Conservation Code (or ASHRAE Standard 90.1-2019 for mid- and high-rise multifamily buildings).

Total cumulative CO_2 reductions equivalent to emissions from

- 59 million cars and light trucks in a year
- 35 million homes in a year
- 1.5 million railcars full of coal
- Florida and Nevada for a year

Affordability. On average this upgrade yields net positive cash flow (the time at which the energy bill savings minus the added mortgage payments pay back the initial expense of a 10% down payment) in 25 months for a single-family house and 17 months for a multifamily unit. The lifetime savings are \$5,700 and \$2,700, respectively. The savings would reduce the percentage of low- and moderate-income households with high energy burdens (i.e., with more than 6% of household income going toward energy bills) from 37% to 31% among owners of covered single-family homes and from 39% to 35% among renters of multifamily units. After accounting for increased mortgage payments, the upgrades would reduce median total housing burdens for those groups by 0.8% and 0.5%, respectively.

Federal loan and grant programs with efficiency requirements. We estimate that 238,000 new homes constructed in 2023 will be subject to federal efficiency requirements. Upgrading these homes would—in just the first year—create about 8,600 jobs, save \$70 million in energy bills, and avoid 0.23 million metric tons of carbon dioxide emissions (MMT CO_2). Table ES1 shows that cumulatively over 30 years, the improved efficiency of these homes alone would save \$1.2 billion net present value (NPV), including energy bill savings and other consumer benefits after the needed investment. It would also result in 17,000 added job-years (total years of employment, including jobs due to energy savings as well as initial construction) and reduce CO_2 emissions by 6.1 million metric tons, equal to the current emissions of one million cars and light trucks for a year.

These savings would compound over years of new construction. We project federal loan and grant programs will serve about 5.8 million new homes by 2050. If we assume rapid improvements in model energy codes—such that they further cut the energy use affected by codes almost by half by 2040—but continued slow code adoption by states and less-than-perfect compliance with the codes, we estimate that updating federal efficiency requirements could save \$8 billion NPV, add 246,000 job-years, and reduce CO_2 emissions by 81 MMT, the emissions of 17 million vehicles for a year. The jobs and emissions impacts for each year appear in blue in figures ES1 and ES2.

GSE loans. Applying the efficiency criteria to new homes with Fannie Mae and Freddie Mac loans would have even greater impact. We estimate the two GSEs combined will buy loans

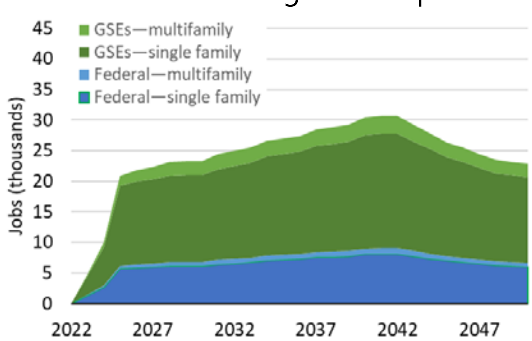

Figure ES1. Net added jobs each year due to efficiency improvements in new homes

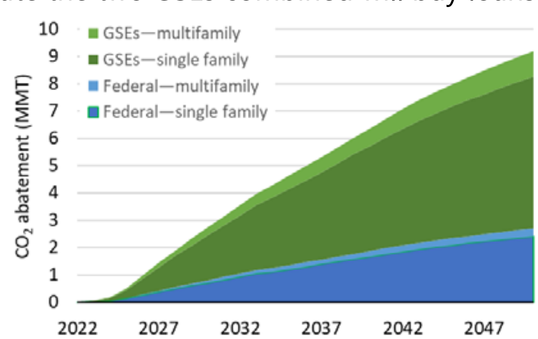

Figure ES2. Reduction in CO_2 emissions each year due to efficiency improvements in new homes

for about 14 million new homes through 2050. Improving the efficiency of those homes could save an additional $19 billion NPV, add 591,000 job-years, and reduce CO_2 emissions by 194 MMT, equivalent to the yearly emissions of 42 million vehicles. These jobs and emissions impacts appear in green in the above figures.

Combined impacts from all new homes receiving federal support through 2050 are in the "Key Takeaways" at the start of this summary and in the box on the previous page.

Beyond codes. To see the impacts of higher efficiency levels, we looked at the new ENERGY STAR for New Homes version 3.2 (1.2 for multifamily) using the Environmental Protection Agency's analysis. The higher efficiency levels, with at least 10% savings compared with the 2021 International Energy Conservation Code (IECC), would nearly double the impacts for federal loan and grant programs, with nearly $17 billion NPV savings, reductions of 154 MMT CO_2, and creation of 430,000 job-years. Switching homes from gas furnaces and water heaters to electric heat pumps would further increase CO_2 reductions, with a slight reduction in both initial cost and energy bill savings.

Table ES1. Cumulative financial, job, and climate impacts from efficiency improvements in new homes versus typical new homes

	One year of new homes			New homes through 2050		
	Net savings ($billion PV)	Jobs created (thousand job-years)	CO_2 emissions avoided (MMT)	Net savings ($billion PV)	Jobs created (thousand job-years)	CO_2 emissions avoided (MMT)
New homes at latest model codes						
HUD, USDA, and VA	1.2	17	6	8.0	246	81
Single-family	1.0	16	6	7.2	222	72
Multifamily	0.1	1	1	0.9	25	9
Fannie and Freddie	2.8	41	15	19.3	591	194
Single-family	2.4	36	13	16.5	511	166
Multifamily	0.4	5	2	2.8	80	28
Total	3.9	58	21	27.4	838	275
New above-code homes						
HUD, USDA, and VA	2.2	28	11	16.6	430	154
New all-electric above-code homes						
HUD, USDA, and VA	2.2	19	14	18.7	291	224

The "HUD, USDA, and VA" rows include Federal Housing Administration (FHA), Department of Veterans Affairs (VA), and Department of Agriculture (USDA) loans and Department of Housing and Urban Development (HUD) programs, all of which have current efficiency requirements. "One year of new homes" shows the impacts over 30 years from new homes built in 2023. "New homes through 2050" shows the impacts over a 30-year lifetime for new homes built through 2050, with frequently updated codes. Because of rounding, individual row entries may not add to the totals shown.

Introduction

Building energy codes set a minimum level of efficiency for new single-family and multifamily homes (and for commercial buildings, which are outside the scope of this paper). These codes set minimum efficiency requirements—usually with multiple options—for insulation, windows, air leakage, duct leakage, thermostats, lighting, and sometimes furnaces, air conditioners, water heaters, and other equipment. The upgrades are important not only to reduce energy bills but also to improve the health and comfort of residents and to reduce air pollution, greenhouse gas (GHG) emissions, peak electric and natural gas demand, and vulnerability to energy price spikes. Codes are typically set at the state or local level and vary widely.

However, the federal government sets efficiency criteria nationwide for many of the new and rehabilitated homes that it supports, which are primarily for low- and moderate-income (LMI) homeowners and renters. These criteria are especially important to protect residents in states with weak—or nonexistent—energy codes. Covered single-family homes include new homes with loan guarantees or insured loans through Federal Housing Administration (FHA), Department of Veterans Affairs (VA), and Department of Agriculture (USDA) mortgages, and to a lesser extent through Department of Housing and Urban Development (HUD) grant programs. Such homes make up about one-fifth of all new single-family homes.

Efficiency criteria also apply to new multifamily homes with FHA mortgages and to new and rehabilitated multifamily homes with support from HUD programs such as HOME Investment Partnerships grants for affordable housing, Rental Assistance Demonstration (RAD) funding that is used to convert public housing to privately owned affordable rental properties, and public housing. Combined, the new homes in these categories represent about one-eighth of all new units in multifamily buildings in recent years.[1]

Energy efficiency is especially important for LMI residents of federally supported housing, who tend to have higher-than-average energy burdens (the proportion of household income going toward energy bills, including for electricity, gas, and other heating fuels). Efficiency is also important for HUD, which spends billions of dollars each year to help pay these bills. HUD has a successful incentive program for multifamily homes, the HUD Green Mortgage Insurance Premium Reduction, under which more than two-thirds of new multifamily units with FHA loans meet one of several green building standards. Fannie Mae and Freddie Mac also have green multifamily programs. But the minimum efficiency requirements for homes with federal support are badly out of date.

National model energy codes are set by independent organizations, the International Code Council and ASHRAE. The International Energy Conservation Code (IECC) for single-family and low-rise multifamily homes and the IECC or ANSI/ASHRAE/IES Standard 90.1 for multifamily buildings of more than three stories (and commercial buildings) are the basis for most state and local codes and federal requirements. To update their requirements to a new model code, HUD and USDA must determine that the update will not harm the "affordability" or "availability" of the affected homes. But they have done this only once, in 2016 for the 2009 IECC and ASHRAE Standard 90.1-2007. The agencies are now four code cycles behind the most recent editions. The VA has not updated its requirements at all.[2] Model energy codes have seen significant progress in some of those cycles, and homes built to the most recent editions, the 2021 IECC and Standard 90.1-2019, are designed to use about one-third less energy than the 2009 IECC and 90.1-2007.

While some federal programs have outdated efficiency requirements, others do not currently have any requirements to prevent energy waste. Most notably, the Federal National Mortgage Association (Fannie Mae) and Federal Home Loan Mortgage Corporation (Freddie Mac), government-sponsored enterprises (GSEs) under the supervision of the Federal Housing Finance Agency, buy almost half of mortgages for home purchases and multifamily buildings but have not set efficiency requirements for new homes. The Low-Income Housing Tax Credit also has no federal energy efficiency requirements, though some states have set their own efficiency incentives or criteria for projects that receive the credit.

This paper examines the impacts on consumer savings, housing burdens, GHG emissions, and jobs of updating efficiency requirements for federally supported housing to the 2021 IECC and Standard 90.1-2019, and of extending the requirements to GSE loans. It also looks at the potential impacts of a higher efficiency level, as embodied in the new ENERGY STAR® New Homes criteria, as well as impacts from making the homes all-electric.

Methodology

To project the impacts of efficiency requirements, we estimated the savings over time for typical homes and multiplied these savings by the estimated number of new homes affected. We describe our basic methods and data sources here, with more detail in Appendix A.

NUMBER OF NEW HOMES

Table 1 shows our estimate of the recent percentage of new homes supported by each program, with data sources noted. To determine the number of new homes covered under each program, the new homes percentage was then multiplied by the estimated number of new single family and multifamily homes each year in the Energy Information Administration's *2022 Annual Energy Outlook* reference case (AEO).[3]

Table 1. Estimated percentage of new homes supported by federal and GSE loans and programs

Single-family program	% of new homes	Multifamily program	% of new homes
HUD, USDA, and VA			
FHA loan	11.8%[4]	FHA loan	9.4%[5]
VA loan	5.6%[6]		
USDA loan	1.6%[7]		
HOME program	0.2%[8]	HOME program	2.4%[8]
		RAD	0.6%[9]
		Public housing	0.5%[10]
Fannie and Freddie			
Fannie Mae loans	25%[11]	Fannie Mae and Freddie Mac	42%[12]
Freddie Mac loans	19%[13]		

Multifamily programs include low-, mid-, and high-rise builings.

COST AND ENERGY AND CARBON SAVINGS

For each single-family and multifamily home, we estimated the cost and savings associated with meeting the current model energy code or reaching beyond-code levels, compared with a current base case. The results presented below combine impacts from low-, mid-, and high-rise multifamily homes. We did not try to account for variations in homes constructed under different programs, although different distributions of home sizes, locations, family sizes, and other characteristics could affect energy use.

For single-family and low-rise multifamily homes, we used the relevant versions of the IECC; for mid-rise and high-rise multifamily units we used the relevant versions of ASHRAE Standard 90.1. We derived energy costs and savings by code from DOE and Pacific Northwest National Laboratory (PNNL) building simulations. For the current base case, we used the blend of energy codes (IECC or ASHRAE 90.1 versions) adopted by states as determined in DOE adoption data as of January 2022.[14] To account roughly for widespread green building programs, we reduced the estimated base case multifamily energy use by 5%.

To see the impact of requiring energy efficiency beyond the model code, we analyzed a second policy case of meeting the new ENERGY STAR Single-Family New Homes Version 3.2 and Multifamily New Construction Version 1.2 using Environmental Protection Agency (EPA) analysis (EPA estimates roughly 10–20% savings compared with the 2021 IECC).[15] We also looked at a third policy case that assumes the homes are all-electric, based on the same estimated energy use for ENERGY STAR homes that use heat pumps.

For all cases, we included direct rebound effects (i.e., the increase in use of an efficient product due to lower energy costs, such as running an efficient air conditioner more), estimated at 10% for homes.[16] We also included estimated upstream energy impacts (i.e., the energy used to drill, produce, refine, and transport the fuel or electricity delivered to the end user) in the analysis for primary energy and GHG savings.[17]

We calculated lifetime savings over 30 years using the AEO forecast for residential energy prices (with trends extended past 2050 as needed) and loans for the costs. Savings are present values in 2021 dollars discounted at a 5% real rate. We calculated carbon dioxide (CO_2) emission reductions from the energy savings using AEO projected average electric system intensities.

We looked at two cases. One is for homes built in 2023 to current model codes (labeled "One year of new homes" in our figures and tables). The other is for new homes through 2050, assuming base case code improvements, energy losses due to noncompliance, and implementation of federal requirements over three years (labeled "New homes through 2050").

Efficiency measures also have benefits for residents beyond energy savings. Less air leakage and less financial strain yield health benefits, while fewer drafts and better windows improve temperature control and comfort. We conservatively included nonenergy benefits of 50% of energy cost savings (before rebound) in our calculation of net savings.[18]

ENERGY BURDEN AND JOBS

To further examine the impacts of efficiency on housing affordability, we used microdata from the U.S. Census Bureau's 2019 *American Housing Survey* to estimate the changes in energy burden and total housing burden (housing costs, including energy costs, as a percentage of household income) resulting from the average added home cost and energy bill savings described above.[19] Burden data are drawn from all homes, not homes under specific programs.

The jobs analysis used a version of our Dynamic Energy Efficiency Policy Evaluation Routine (DEEPER) input–output model, based on 2019 IMPLAN data. We estimated how many jobs would be created and lost due to the added investment in efficiency measures and loan interest payments, corresponding reduction in other consumer spending, consumer energy bill savings, and the consequent reduction in payments to utilities. We included direct, indirect, and induced job impacts resulting from those shifts in funds in construction, manufacturing, the energy sector, and throughout the economy. We did not include job impacts from nonenergy benefits, but those would not be large. Jobs are counted as the net increase or decrease in the number of full-time-equivalent jobs by year, aggregated as "job-years." The economic analysis methodology is more fully described in previous work.[20]

Results

We start by discussing impacts from meeting the latest model energy codes on affordability for individual households and on energy and housing burdens. We then discuss national impacts from improving one year's worth of homes to meet current model codes, first covering homes with FHA loans or other federal support that have current efficiency requirements, and then looking at impacts if similar requirements were applied to new homes with Fannie Mae and Freddie Mac loans. A discussion of a second scenario with many years of construction under improving codes follows. The last results are for similar scenarios with beyond-code efficiency (only for homes under federal programs, not those with GSE loans). In order to ease comparison, some figures and tables will include results that we have yet to describe in the text.

RESIDENT SAVINGS AND ENERGY BURDENS

On the basis of the building modeling described above, requiring homes to be more efficient will typically make the homes more affordable, with significant savings for residents. Table 2 shows the cost and savings for the average home built in 2023 (in 2021 dollars). Upgrading homes from current baseline efficiency (based on current code adoption around the country, as described above and in Appendix A) to meet the 2021 IECC or Standard 90.1-2019 yields thousands of dollars in savings. We find a discounted net present value of $5,743 for single-family homes and $2,687 for multifamily units. That includes an upfront cost, estimated as $3,399 for a single-family home; for context, in 2021 the median sales price for a new home was $393,000 ($283,000 for homes with FHA loans).[21]

Net positive cash flow (achieved when the cumulative energy bill savings minus the added mortgage payments pay back the initial expense of a 10% down payment) takes about two years on average. Most multifamily residents are renters, to whom the cash flow analysis does not directly apply, but two competing factors affect the multifamily time to positive cash flow in this analysis: The time is lengthened because we assume a 15-year loan with higher monthly payments (after 15 years the energy savings will continue with no added cost), but the time is shortened for high-rise multifamily (not shown separately here) because downsizing of heating and cooling equipment yields upfront savings and hence instant payback.

Table 2. Household-level cost, energy savings, and other benefits of meeting 2021 IECC/90.1-2019

	Initial cost ($)	Annual energy savings ($)	Time to positive cash flow (years)	Lifetime net benefits ($)	Financial-only net savings ($)
Single family	3,399	340	2.1	5,743	2,794
Multifamily (avg.)	947	143	1.4	2,687	1,445
Combined	2,885	299	2.0	5,102	2,511

Nonenergy benefits represent roughly 50% of the lifetime net benefits but are not included in the financial-only savings; both are net present value. All results are relative to a base case of current construction.

Though income requirements vary, the occupants of homes supported by federal loans and grant programs are disproportionately LMI homeowners and renters. Extensive literature has shown that LMI households experience disproportionately high energy burdens, which can lead to adverse consequences when these households are required to choose between energy costs and other essential expenditures.[22] Increasing efficiency can lower these households' overall housing costs.

To further examine the effects of efficiency on affordability, we looked at current energy and housing burdens and the impact of building to updated model codes. Figure 1 shows that improving the energy efficiency of homes would modestly reduce the share of residents paying a high percentage of their income on energy bills and on total housing costs. Among LMI owners of single-family homes, the estimated $340 reduction in annual energy bills from meeting the latest model codes would reduce the share of households with high energy burdens from 37.4% to 31.2%. After including other housing costs, the share of LMI owners with high housing burdens would dip from 71% to 70%. While this impact may seem small, it still represents, as described above, $2,794 net lifetime financial savings and equally significant nonenergy benefits such as increased comfort and better health outcomes.

The impacts on LMI renters of multifamily units are similar. For the 70–80% of these renters who pay their energy bills,[23] the $143 average annual energy savings would reduce the share with high energy burdens from 38.5% to 34.7%. Assuming added costs are passed on to them in rent charges, it would slightly reduce the share with high total housing cost burdens from 80% to 79%. Tables B7 and B8 in Appendix B present detailed results, including for other subgroups.

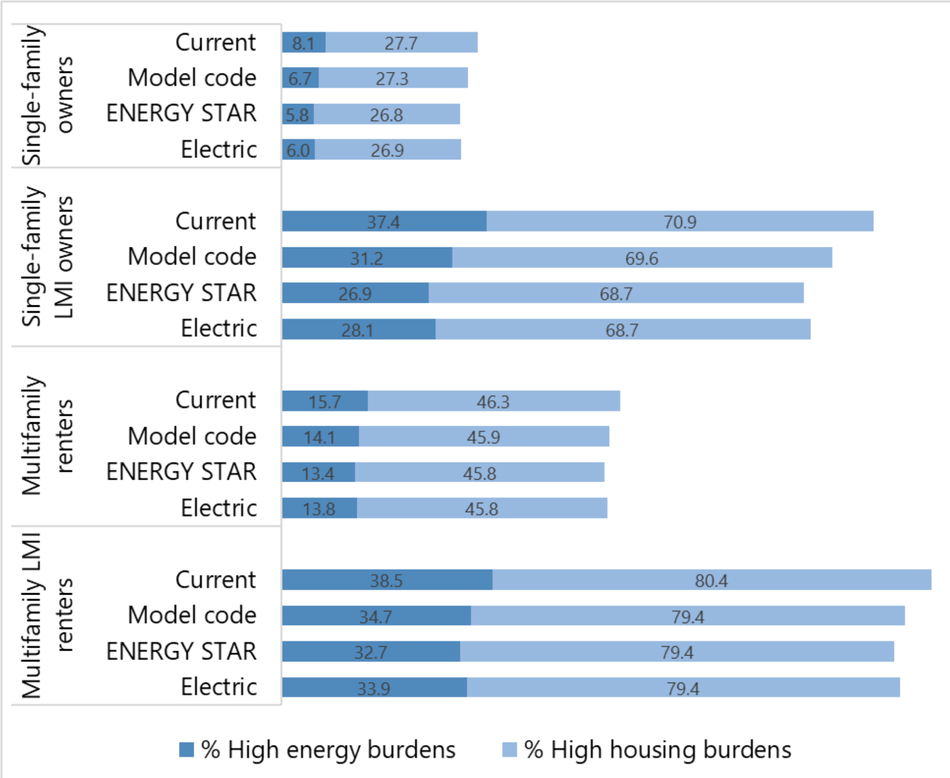

Figure 1. Percentage of households with high energy and housing burdens. High energy burden refers to energy costs greater than 6% of income. High housing burden refers to total housing costs greater than 30% of income. LMI households have income below 300% of the federal poverty level. All single-family data are calculated only for residents who have mortgages (as policy is for single-family loans). Multifamily data are limited to renters (as policy is for multifamily loans and programs). All data are limited to residents of homes built after 2010.

NATIONAL COST SAVINGS, CARBON ABATEMENT, AND JOBS CREATED

Impacts of Meeting Current Model Codes

Federal loans and programs with efficiency requirements. Updating efficiency requirements for the estimated 188,000 single-family and 50,000 multifamily homes to be built in 2023 with FHA loans or other federal support would reduce energy bills by $70 million and CO_2 emissions by 0.23 million metric tons (MMT) in the first year. The blue blocks in the left half of figure 2 (and the first part of table B1 in Appendix B) show the cumulative discounted impacts over 30 years from those homes built in 2023: $0.5 billion in investment yields more than twice that amount in energy bill savings and additional consumer benefits. Added together, these yield net present value savings of $1.2 billion.

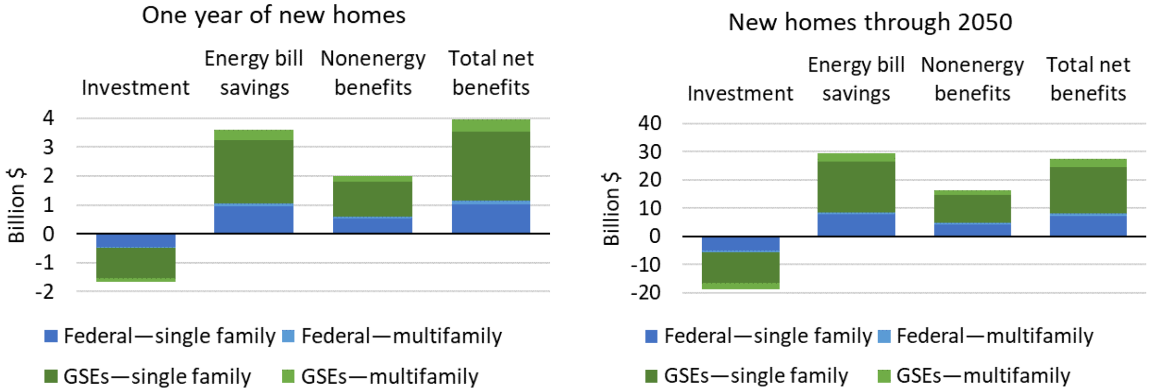

Figure 2. Present value of lifetime costs and savings ($billion) from meeting up-to-date model codes. "One year of new homes" shows the impacts over 30 years from new homes built in 2023. "New homes through 2050" shows the impacts over a 30-year lifetime for new homes built through 2050, with frequently updated codes.

As shown by the blue blocks in figure 3 (and detailed in the first part of table B1), improving homes built in 2023 to meet up-to-date model codes will, over 30 years, reduce cumulative CO_2 emissions by 6.1 MMT, equal to the current annual emissions of more than one million cars and light trucks. Savings by energy source are shown in table B5.

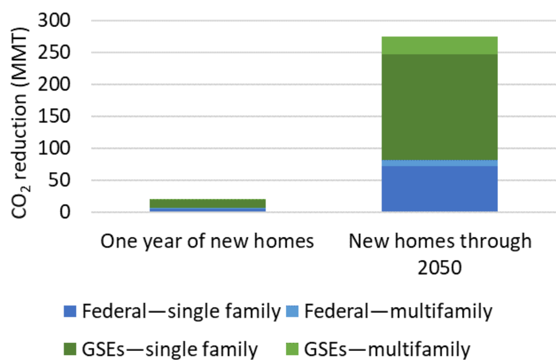

Figure 3. Cumulative CO_2 reductions (MMT) from meeting up-to-date model codes, for homes built in 2023 and for homes built through 2050.

As shown in blue on the left in figure 4 (and detailed in the first part of table B3), we estimate the investment in greater efficiency will result in roughly 8,600 more jobs in the first year (2023) and 17,000 more people working for a year (job-years) over the lifetime of the improvements due to reduced energy bills and increased mortgage payments (taking into account jobs lost due to less spending in other sectors).

The total impacts are much larger for single-family than for multifamily homes because there are more covered single-family homes and because each home has higher energy use and thus more potential savings (and because the average initial investment is so small for multifamily homes).

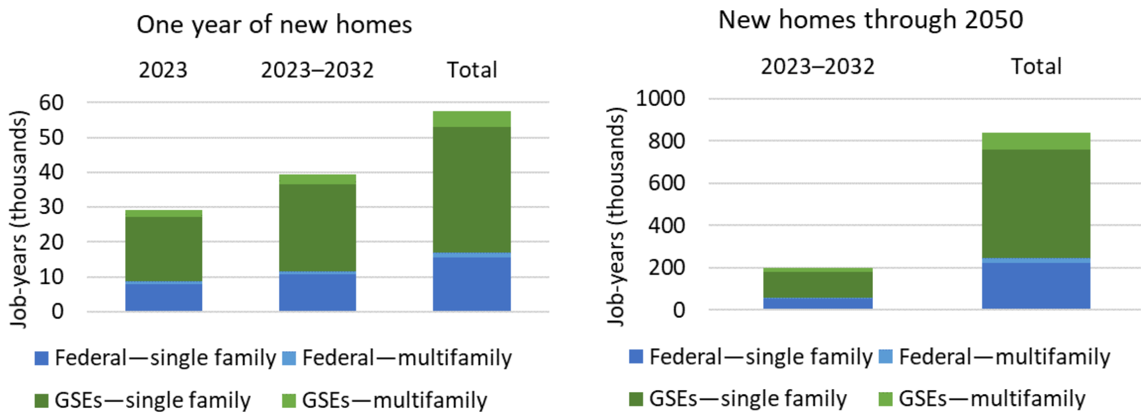

Figure 4. Net jobs added by meeting up-to-date model codes for homes built in 2023 and for homes built through 2050 (thousand job-years).

Fannie Mae and Freddie Mac loans. Applying the same efficiency criteria to new homes with Fannie Mae and Freddie Mac loans would have even greater impact, as shown in green in figures 2, 3, and 4 (and detailed in tables B1 and B3). More than twice as many new homes are purchased with these loans, we believe, and we estimate that upgrading one year of these homes to meet current model codes would save $2.8 billion NPV, reduce cumulative CO_2 emissions by nearly 15 MMT, and add 41,000 job-years.

Impacts from Construction Through 2050

To understand the larger potential of efficiency upgrades, we projected impacts for construction of homes through 2050, estimating that 4.6 million single-family homes and 1.2 million multifamily units would be affected. We assumed rapid base case code improvements, gradual base case adoption of and compliance with the codes, and effective implementation of the efficiency criteria. As shown in the right half of figures 2 and 3 (and detailed in the second half of table B1), savings for federal loans and programs grow to $8 billion NPV and 81 MMT CO_2, equivalent to the emissions of 17 million vehicles for a year. If the new code is applied to Fannie Mae and Freddie Mac, the added savings would be $19.3 billion and 194 MMT CO_2, the emissions of 42 million vehicles for a year. Figure 5 shows the growth in emissions abatement by year (and the decline after 2052, as we include only 30 years of savings for homes built from 2023 through 2050).

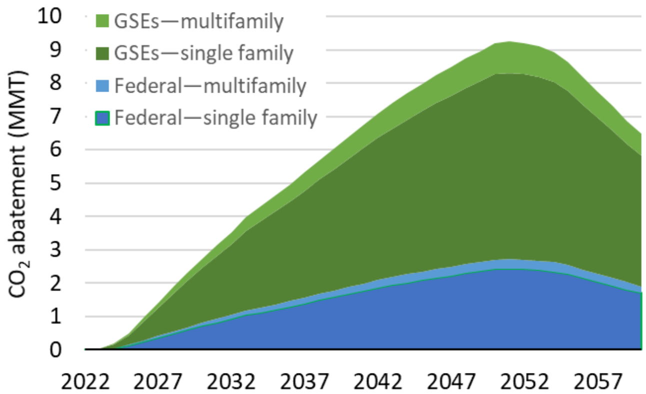

Figure 5. Reduction in CO_2 emissions each year due to meeting up-to-date model codes in new homes built through 2050

Job creation is, of course, much more spread out, but over the lifetime of the homes, the improvements for homes under federal loans and programs would add 246,000 job-years, and those for homes with Fannie Mae and Freddie Mac loans could add 591,000 job-years (shown in figure 4 and table B3). Figure 6 shows the net jobs added over time. The number of jobs increases with added investment for each code edition; then, after we stop assuming new codes, it decreases as the base case codes start to catch up. The analysis includes no new construction after 2050, but some job impacts continue due to continued energy savings and loan payments.

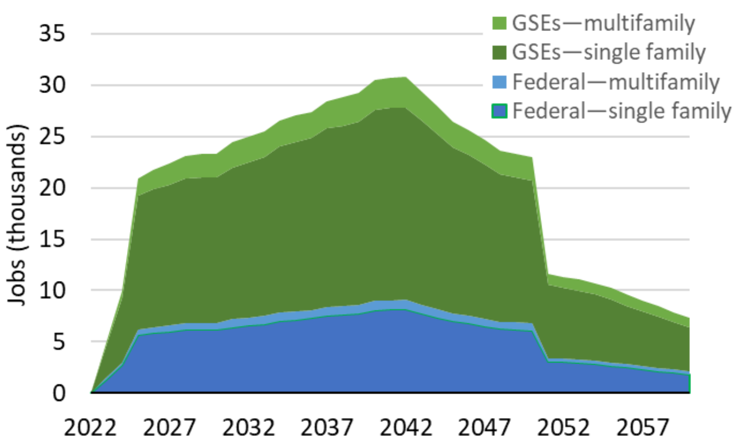

Figure 6. Net added jobs each year due to meeting up-to-date model codes in new homes built through 2050 (with job impacts continuing after 2050 because of continued energy savings and loan payments)

Adding together new homes under all the loans and programs yields a reduction of 275 MMT CO_2, equal to the emissions of 59 million vehicles for a year, 35 million homes for a year, or 1.5 million railcars full of coal.[24] They also yield $27.4 billion NPV savings and 838,000 job-years.

BEYOND-CODE SAVINGS

To look at the impacts of adopting efficiency criteria beyond the model code levels, we analyzed homes that meet the new ENERGY STAR levels for new homes based on the 2021 IECC (3.2 for single family and 1.2 for multifamily). These criteria are designed to achieve at least 10% savings compared with the model code, and EPA estimates savings of roughly 10–20%. The first half of table 3 shows results for ENERGY STAR homes relative to a base case of current construction, comparable to earlier results for meeting model codes.

Table 3. Household-level cost, energy savings, and other benefits from meeting ENERGY STAR 3.2/1.2 and for all-electric ENERGY STAR homes

	Initial cost ($)	Annual energy savings ($)	Time to positive cash flow (years)	Lifetime net benefits ($)	Financial-only net savings ($)
ENERGY STAR 3.2/1.2					
Single family	4,945	603	1.4	10,972	5,747
Multifamily (avg.)	2,088	241	2.8	4,099	2,012
Combined	4,347	527	1.5	9,532	4,964
All-electric ENERGY STAR 3.2/1.2					
Single family	3,689	534	1.1	10,836	5,611
Multifamily (avg.)	153	178	0.1	4,739	2,653
Combined	2,948	460	1.0	9,558	4,991

Lifetime net benefits include additional resident benefits equal to 50% of the energy savings for ENERGY STAR homes (not included in the financial-only savings); both are net present value. All results are relative to a base case of current construction with a blend of fuels.

Stronger criteria would significantly increase the savings. Energy and housing burdens, as shown in figure 1 above, are slightly reduced. Figures 7–9 (and tables B2 and B4) show results for new homes with federal loans or under federal programs. The energy savings, net savings, CO_2 reductions, and jobs increase 65–110% for single-family homes and increase 50–75% for multifamily homes relative to just meeting the model codes. For homes constructed through 2050 the savings increase to $16.6 billion NPV, 154 MMT CO_2 (equal to the emissions of 33 million vehicles for a year), and nearly 430,000 job-years.

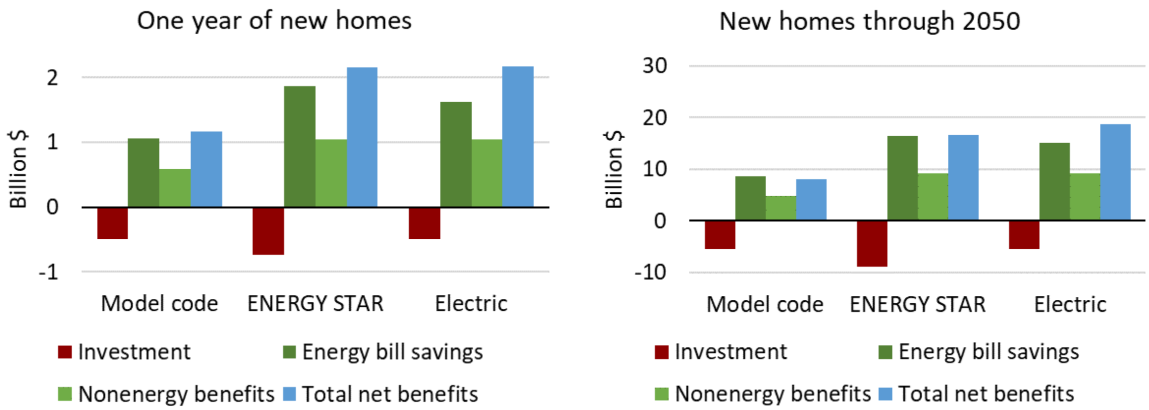

Figure 7. Present value of lifetime costs and savings ($billion) from meeting up-to-date model codes, above-code efficiency, and all-electric and above-code, for homes built in 2023 and for homes built through 2050

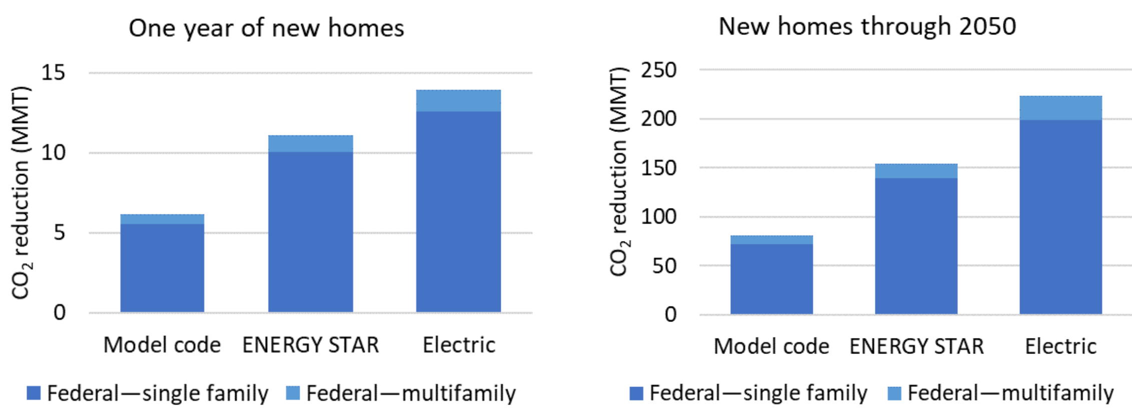

Figure 8. Cumulative lifetime CO_2 reductions (MMT) from meeting up-to-date model codes, above-code efficiency, and all-electric and above-code, for homes built in 2023 and for homes built through 2050. See text for a discussion of sensitivity to assumptions about the electric grid.

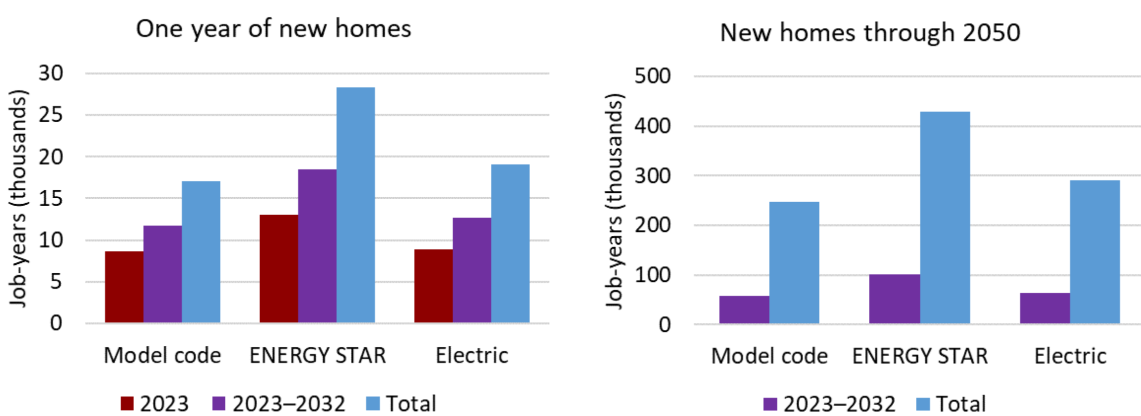

Figure 9. Net jobs added (thousand job-years) due to meeting up-to-date model codes, above-code efficiency, and all-electric and above-code, for homes built in 2023 and for homes built through 2050

ELECTRIFICATION IMPACTS

We also looked at the impacts of electrification with a case in which data for ENERGY STAR homes that use natural gas are shifted to reflect the energy use and costs of ENERGY STAR all-electric homes, with heat pump heating, cooling, and water heating. Table 3, figure 1, and figures 7–9 (and tables B2 and B4) show results for new efficient electric homes with federal loans or under federal programs compared with the current construction base case with a blend of energy sources. These homes have reduced initial costs because a heat pump is cheaper than the combined cost of a furnace and air conditioner; they also have reduced GHG emissions because of the switch from natural gas and oil to electricity. However, the net cost savings are somewhat lower because the energy bills for the added electricity are higher than the avoided gas bills, based on the EPA prototype homes and energy prices projected in the Energy Information Administration's Annual Energy Outlook. And job creation is lower because of less construction, smaller bill savings, and the shift from natural gas to electricity. For homes constructed through 2050, the savings are $18.7 billion NPV, 224 MMT CO_2 or the emissions of 48 million vehicles for a year, and 291,000 job-years.

The long-term impacts of switching to electricity are highly sensitive to the future electric and natural gas systems. If—as a nation—we pursue strong climate policies, electric generation will result in less carbon emissions, and the carbon impacts will increase. If instead of using AEO carbon intensity we assume that saved electricity will be generated from 80% zero-carbon sources by 2035 and 100% by 2050, the carbon abatement from improving home efficiency will be reduced in all scenarios as the electric savings are less carbon-intensive. But the cumulative impact from shifting efficient fossil fuel homes built through 2050 to use electric heat pumps increases from 70 MMT CO_2 to 115 MMT CO_2. If fewer homes use natural gas, that also could increase natural gas prices as the costs of the distribution pipeline network are spread over fewer customers.[25] That would yield energy cost savings from switching to electricity (although higher electric prices from zero-carbon generation or lower bulk natural gas prices due to lower demand could reduce those savings).

Conclusion

The cheapest and easiest time to avoid energy waste in a home, as well as prevent drafts and outdoor air pollution from entering, is when the home is built. Although building energy codes are generally developed by independent organizations and adopted by states and cities, the federal government sets efficiency requirements for a significant fraction of new homes. Those requirements are badly out of date—more so than the energy codes in most states. Simply adopting the newest model energy codes offers $1.2 billion in net cost savings for homes built each year, 6.1 million tons of greenhouse gas reductions, and 17,000 added jobs. Those savings and jobs could be greatly increased by setting a higher energy efficiency threshold, such as ENERGY STAR, or tripled by extending the requirements to new homes with Fannie Mae and Freddie Mac mortgages. If there are concerns about requiring above-code efficiency levels, financing incentives seem to have been effective in shifting a large part of multifamily construction to greener homes and should be strengthened and expanded to single-family homes. For both requirements and incentives, monitoring and boosting compliance also are important. The federal government should lead the way toward better homes that are cheaper to live in and do not pollute.

Appendix A. Methodology Details

Here are more specifics about some of the assumptions we used for this report.

Number of covered homes: We estimated the number of new homes covered by each program from the average percentage of new homes over 2018–2020 (because there was significant fluctuation). For most of the federal loans and programs, we found data on the number of new single-family homes and multifamily units and divided each by the total number of new homes or units in that year in U.S. Census data. We could not find sources on the number of new homes with USDA and GSE loans, so we used the percentage of purchase loans or of all loans under the program and multiplied by the percentage of new homes with loans. We did not try to account for overlap—some homes are supported by more than one program, but there are also programs for which we did not find usable data. In any case, most of the homes have FHA loans or GSE loans, so the effect of overlap with HUD programs on the overall results would be fairly small.

Because we did not have estimates for new construction of low-rise versus high-rise multifamily homes, we allocated multifamily homes on the basis of U.S. Census data on the percentage of homes in existing buildings with two or more units that have at least four stories (23%).[19]

Base case homes: To assign code versions to each state, we used PNNL's residential and commercial energy use indexes (EUIs) for each state compared with the EUIs for the code versions in that state; because many states have adopted codes slightly weaker than a national model, we counted a state as meeting a model code version if the index is two-thirds of the way to that code relative to the previous code. We assigned most states with no index to the lowest code (2006 IECC or 90.1-2004). However, to account for local codes, we assigned states with no DOE index that are listed in the *ACEEE State Energy Efficiency Scorecard* as having significant local adoption to one code weaker than in the *Scorecard*.[26] Table A1 shows the resulting current distribution of homes.

Table A1. Estimated percentage of new homes by approximate code version (January 2022)

	Single family	Low-rise multifamily		High-rise multifamily
≤ 2006 IECC	11.3%	8.9%	≤ 90.1-2004	4.9%
2009 IECC	18.6%	15.3%	90.1-2007	9.2%
2012 IECC	40.5%	37.5%	90.1-2010	10.3%
2015 IECC	16.4%	14.0%	90.1-2013	54.0%
2018 IECC	4.5%	8.8%	90.1-2016	3.9%
2021 IECC	8.8%	15.5%	90.1-2019	17.7%

To estimate the national average energy use and added costs by code version, we derived 2009, 2012, and 2015 IECC first costs and savings by aggregating PNNL state-level data, 2018 and 2021 IECC savings from DOE determinations (converting site and source energy use to electric and fuels energy use, and dividing fuels energy use into natural gas and oil based on their assumed oil versus gas furnace distribution), and 2018 and 2021 costs from the cost-effectiveness analyses.[27] We added 20% for single family and 30% for multifamily to the 2021 IECC cost to account for replacement and maintenance costs (adjusted down from PNNL estimates because we use a higher discount rate). For mid- and high-rise multifamily, we took energy savings and weightings from PNNL end-use tables; we took PV first, replacement, and maintenance costs for mid-rise from PNNL cost-effectiveness analyses.[28] PNNL does not analyze costs for high-rise multifamily, so we used the mid-rise costs per square foot for high-rise as well. For simplicity, we treated the PV costs as first costs in our analysis. To account for significant construction of multifamily to green building standards, spurred by financing incentives, we reduced the multifamily base case use of all energy sources by 5% from code levels. Table A2 shows the estimated savings and costs by code.

We used EPA's estimated energy use and added cost of ENERGY STAR homes compared with the 2021 IECC by climate zone and aggregated over the zones and fuel types using DOE's weighting factors. Because EPA did not include prototype homes that use oil as a fuel, we allocated a small percentage of EPA's estimated natural gas savings to fuel oil based on PNNL's fuel use distribution. For an electrification cost (actually cost savings), we estimated the cost difference between EPA's prototypes for natural gas and electric homes that meet 2021 IECC using DOE's estimated costs for installed equipment in the most recent standards rulemakings.[29] We then added EPA's estimated costs for earning ENERGY STAR in both cases.

We inflated all costs to 2021 dollars using a GDP chained price index. The cost estimates generally do not reflect recent price spikes due to supply and demand disruptions during the epidemic, but all calculations are in constant dollars, and the long-term effects on home prices versus general inflation are not yet clear.

Table A2. Estimated energy savings and cost increase by code cycle (or beyond-code criteria)

Single family	2009 IECC	2012 IECC	2015 IECC	2018 IECC	2021 IECC	ENERGY STAR	Electric
Electricity (kWh)	1,637	2,130	31	136	1,274	1,536	–2,351
Natural gas (MMBtu)	5.35	12.92	0.14	0.46	3.32	7.38	18.99
Fuel oil (gallon)	1.6	4.1	0.0	0.1	0.8	1.75	4.49
Cost ($)	1,113	2,094	5	52	2,846	1,547	–1,256
Low-rise multifamily							
Electricity (kWh)	516	478	61	89	920	575	–1,677
Natural gas (MMBtu)	1.24	2.96	0.32	0.05	2.77	2.68	11.73
Fuel oil (gallon)	0.4	0.9	0.1	0.0	0.7	0.76	3.33
Cost ($)	549	1,081	38	39	1,711	1,141	–1,938
Mid/High-rise multifamily	**90.1-2007**	**90.1-2010**	**90.1-2013**	**90.1-2016**	**90.1-2019**	**ENERGY STAR**	**Electric**
Electricity (kWh)	339	322	780	490	232	Same as low-rise	
Natural gas (MMBtu)	1.31	2.82	3.64	–0.06	0.38		
Cost ($)	287	377	532	–1,123	–1,736		

Savings cases and financing. We looked at two temporal scopes of homes (as well as two sets of programs). One is for homes built in 2023 to the 2021 IECC or Standard 90.1-2019. The other is for new construction through 2050. For the latter, we optimistically assumed a scenario in which model codes improve to require zero-energy-ready homes: that future model codes would save 10% of all energy sources every three years through the 2039 IECC and 90.1-2037 (10% of covered energy use for IECC and of whole-building energy use for 90.1). In the base case we assumed gradual adoption of the model codes (10% of homes in the first year and 10% additional each year starting in the third year) and gradually decreasing noncompliance (20% initial loss of savings, decreasing 10% each year). In the policy cases we still assumed 10% adoption in the first year, then assumed that the agencies would apply the codes to an added 30% of covered homes in each of the next three years, with the same losses due to noncompliance.

We assumed that 90% of added home costs are financed for single family in 30-year mortgages and for multifamily in 15-year commercial loans, both at 2% above the AEO forecast 10-year Treasury rate (3.36% nominal rate for 2023 homes).

Energy burdens. From the U.S. Census 2019 American Housing Survey microdata we selected households that paid their own energy bills, that occupied homes built in 2010–2019, and that had mortgages (for single-family homes) or rented (for multifamily homes). We also looked at subgroups, including low- and moderate-income households, which we defined as having an income under 300% of the federal poverty level. We amortized life-cycle energy savings and life-cycle added costs (including down payment and loan payments) for homes constructed in 2023 to get annualized costs and savings. Using the Census microdata, we then looked at the effect of reduced energy bills on energy burden (energy costs including electricity, natural gas, oil, and other fuels divided by household income before taxes) and of added costs and reduced energy bills on total housing burden (energy costs plus other housing costs including loan payments or rent, taxes, insurance, homeowners association fees, and maintenance divided by household income).

Jobs calculations. We assumed that 60% of the added investment for efficiency improvements would go into residential construction, 20% into manufacturing, and 20% into services. For multifamily homes we assumed 75% of the costs and savings would go to the residents and 25% to landlords, based on the percentage who pay multifamily energy bills.[23] The DEEPER model distributes savings and costs for single-family and multifamily residents among several economic sectors; for landlords we used Other Real Estate.

Appendix B. Additional Results

Table B1. Present value of costs and savings ($billion), and cumulative CO_2 reductions (MMT), from meeting model codes

	Investment	Energy bill savings	Nonenergy benefits	Total net benefits	CO_2 emissions
One year of new homes at 2021 IECC/90.1-2019					
HUD, USDA, and VA	0.5	1.1	0.6	1.2	6.1
Single family	0.5	1.0	0.5	1.0	5.5
Multifamily	0.0	0.1	0.1	0.1	0.6
Fannie and Freddie	1.2	2.5	1.4	2.8	14.7
Single family	1.0	2.2	1.2	2.4	12.8
Multifamily	0.1	0.3	0.2	0.4	1.9
Total	1.6	3.6	2.0	3.9	20.9
New homes through 2050 with improving codes					
HUD, USDA, and VA	5.4	8.7	4.8	8.0	80.9
Single family	4.8	7.7	4.3	7.2	72.3
Multifamily	0.6	1.0	0.5	0.9	8.6
Fannie and Freddie	13.1	20.9	11.6	19.3	194.4
Single family	11.0	17.7	9.8	16.5	166.4
Multifamily	2.1	3.2	1.8	2.8	28.0
Total	18.6	29.5	16.4	27.4	275.3

Table B2. Present value of costs and savings ($billion), and cumulative CO_2 reductions (MMT), from above-code homes and all-electric homes

	Investment	Energy bill savings	Nonenergy benefits	Total net benefits	CO_2 emissions
One year of new homes at ENERGY STAR 3.2/1.2					
HUD, USDA, and VA	0.7	1.9	1.0	2.2	11.1
Single family	0.7	1.7	0.9	2.0	10.0
Multifamily	0.1	0.2	0.1	0.2	1.0

	Investment	Energy bill savings	Nonenergy benefits	Total net benefits	CO_2 emissions
New homes through 2050 at above-code levels					
HUD, USDA, and VA	**8.9**	**16.4**	**9.1**	**16.6**	**154.2**
Single family	7.7	14.8	8.2	15.3	139.2
Multifamily	1.2	1.6	0.9	1.3	15.0
One year of all-electric ENERGY STAR 3.2/1.2 new homes					
HUD, USDA, and VA	**0.5**	**1.6**	**1.0**	**2.2**	**13.9**
Single family	0.5	1.5	0.9	1.9	12.6
Multifamily	0.0	0.1	0.1	0.2	1.4
New all-electric above-code homes through 2050					
HUD, USDA, and VA	**5.6**	**15.1**	**9.1**	**18.7**	**224.0**
Single family	5.3	13.7	8.2	16.6	199.1
Multifamily	0.2	1.4	0.9	2.1	24.9

Table B3. Net jobs added due to meeting model codes (job-years)

	In 2023	2023–2032	2023–2080
One year of new homes at 2021 IECC/90.1-2019			
HUD, USDA, and VA	**8,634**	**11,669**	**17,005**
Single family	8,041	10,854	15,593
Multifamily	593	816	1,412
Fannie and Freddie	**20,446**	**27,649**	**40,504**
Single family	18,518	24,996	35,911
Multifamily	1,928	2,653	4,593
Total	**29,080**	**39,318**	**57,509**
New homes through 2050 with improving codes			
HUD, USDA, and VA	**1,440**	**58,561**	**246,494**
Single family	1,323	52,974	221,786
Multifamily	117	5,587	24,708
Fannie and Freddie	**3,427**	**140,174**	**591,148**
Single family	3,047	121,999	510,777

	In 2023	2023–2032	2023–2080
Multifamily	381	18,175	80,371
Total	4,867	198,735	837,643

Jobs in 2023 are higher in results for one year of new homes than in results for new homes through 2050 because in the first scenario we assumed full compliance in 2023, but in the second we assumed more gradual implementation and compliance.

Table B4. Net jobs added by above-code homes and all-electric homes (job-years)

	In 2023	2023–2032	2023–2080
One year of new homes at ENERGY STAR 3.2/1.2			
HUD, USDA, and VA	13,061	18,496	28,277
Single family	11,768	16,940	25,799
Multifamily	1,293	1,556	2,479
New homes through 2050 at above-code levels			
HUD, USDA, and VA	3,043	101,750	429,616
Single family	2,672	90,721	386,860
Multifamily	370	11,029	42,756
One year of all-electric ENERGY STAR 3.2/1.2 new homes			
HUD, USDA, and VA	8,878	12,650	19,102
Single family	8,766	12,269	18,248
Multifamily	112	380	854
New all-electric above-code homes through 2050			
HUD, USDA, and VA	1,528	63,312	290,755
Single family	1,585	61,150	271,756
Multifamily	–57	2,162	18,999

Jobs in 2023 are higher in results for one year of new homes than in results for new homes through 2050 because in the first scenario we assumed full compliance in 2023, but in the second we assumed more gradual implementation and compliance.

Table B5. Cumulative energy savings from one year of new homes

	Electricity (TWh)	Natural gas (TBtu)	Oil (million barrels)	Total source energy (TBtu)
One year of new homes at 2021 IECC/90.1-2019				
HUD, USDA, and VA	12.1	45	0.3	159
Single family	10.8	41	0.3	143
Multifamily	1.3	4	0.0	16
Fannie and Freddie	29.1	106	0.7	381
Single family	24.9	94	0.6	330
Multifamily	4.2	13	0.1	51
Total	41.1	151	1.0	540
One year of new homes at ENERGY STAR 3.2/1.2				
HUD, USDA, and VA	20.7	86	0.5	282
Single family	18.6	78	0.5	256
Multifamily	2.1	8	0.0	27
One year of all-electric ENERGY STAR 3.2/1.2 new homes				
HUD, USDA, and VA	6.5	199	1.1	284
Single family	6.7	175	1.0	259
Multifamily	-0.2	24	0.1	25

Table B6. Cumulative energy savings from new homes through 2050

	Electricity (TWh)	Natural gas (TBtu)	Oil (million barrels)	Total source energy (TBtu)
New homes through 2050 with improving codes				
HUD, USDA, and VA	177.3	615	4.4	2,233
Single family	155.9	559	4.1	1,985
Multifamily	21.4	56	0.3	248
Fannie and Freddie	428.7	1,468	10.4	5,379
Single family	359.0	1,286	9.3	4,571
Multifamily	69.7	182	1.0	808
Total	606.1	2,083	14.8	7,612

	Electricity (TWh)	Natural gas (TBtu)	Oil (million barrels)	Total source energy (TBtu)
New homes through 2050 at above-code levels				
HUD, USDA, and VA	**313.6**	**1,268**	**8.0**	**4,154**
Single family	280.2	1,156	7.4	3,738
Multifamily	33.4	112	0.6	416
New all-electric above-code homes through 2050				
HUD, USDA, and VA	**88.4**	**3,333**	**17.5**	**4,549**
Single family	90.0	2,915	15.4	4,088
Multifamily	–1.6	418	2.1	460

Table B7. Median energy and housing burdens

	Median energy burden (%)				Median housing burden (%)			
	Current	2021 IECC/ 90.1-2019	ENERGY STAR	Electric ENERGY STAR	Current	2021 IECC/ 90.1-2019	ENERGY STAR	Electric ENERGY STAR
Single family								
All	2.1	1.8	1.6	1.6	21.8	21.6	21.4	21.4
Black	2.7	2.2	2.0	2.0	25.4	25.1	24.9	24.9
Hispanic	2.5	2.0	1.7	1.8	24.4	24.3	24.1	24.1
White	2.0	1.7	1.5	1.6	21.0	20.8	20.6	20.6
Older (65+)	2.8	2.3	2.0	2.1	29.5	29.2	28.9	28.9
LMI	5.0	4.4	3.7	3.8	42.3	41.9	41.4	41.5
Multifamily								
All	2.0	1.7	1.5	1.7	28.2	28.0	28.0	27.9
LMI	4.4	3.9	3.5	3.7	51.4	51.1	51.0	50.9

LMI households have income below 300% of the federal poverty level. All single-family data are calculated only for residents who have mortgages (as policies are for single-family loans). Multifamily data are limited to renters (as policies are for multifamily landlords and rental properties). All data are limited to residents of homes built after 2010.

Table B8. Percentage of households with high energy and housing burdens

	High energy burdens (%)				High housing burdens (%)			
	Current	2021 IECC/ 90.1-2019	ENERGY STAR	Electric ENERGY STAR	Current	2021 IECC/ 90.1-2019	ENERGY STAR	Electric ENERGY STAR
Single family								
All	8.1	6.7	5.8	6.0	27.7	27.3	26.8	26.9
Black	12.4	9.5	8.8	8.8	36.6	35.9	35.4	35.4
Hispanic	9.6	8.5	5.8	5.8	33.2	32.9	32.3	32.9
White	7.6	6.2	5.5	5.8	25.7	25.2	24.6	24.6
Older (65+)	16.4	10.1	7.4	9.0	48.7	47.3	47.3	47.3
LMI	37.4	31.2	26.9	28.1	70.9	69.6	68.7	68.7
Multifamily								
All	15.7	14.1	13.4	13.8	46.3	45.9	45.8	45.8
LMI	38.5	34.7	32.7	33.9	80.4	79.4	79.4	79.4

High energy burden refers to energy costs greater than 6% of income. High housing burden refers to total housing costs greater than 30% of income. LMI households have income below 300% of the federal poverty level. All single-family data are calculated only for residents who have mortgages. Multifamily data are limited to renters. All data are limited to residents of homes built after 2010.

Endnotes

[1] Other HUD programs also have efficiency or green building requirements, including Community Development Block Grant Disaster Recovery funds and the Housing Trust Fund. The Department of Energy recently updated the requirement for federal buildings and privatized military housing to meet the 2021 IECC or Standard 90.1-2019 and, if life-cycle cost-effective, achieve 30% further savings (87 FR 19595 and 87 FR 20267).

[2] For more on the legal requirements, history, and implementation see L. Ungar, *A Buildings Efficiency Agenda for 2021: Federally Assisted Housing and Finance* (Washington, DC: ACEEE, 2020), www.aceee.org/topic-brief/2020/11/buildings-efficiency-agenda-2021. The VA is under a separate statutory provision that is more ambiguous on the need for updates.

[3] EIA (Energy Information Administration), *Annual Energy Outlook 2022* (Washington, DC: EIA, 2022), www.eia.gov/outlooks/aeo/. The number of new homes can be calculated using the survival rates in the documentation.

[4] Data provided by HUD (June 16, 2021). New single-family homes with FHA loans: 2018: 94,156; 2019: 94,496; and 2020: 125,570.

[5] HUD, "FHA MF and OHP Firm Commitments and Endorsements Database FY01_FY22 Q2" (2022), www.hud.gov/program_offices/housing/mfh/mfdata/mfproduction. Initial endorsements for activity "New Construction."

[6] Census Bureau, "Annual Characteristics of New Housing: Financing" (2021), www.census.gov/construction/nrc/index.html.

[7] CFPB (Consumer Financial Protection Bureau), *Data Point: 2020 Mortgage Market Activity and Trends* (Washington, DC: CFPB, 2021), www.consumerfinance.gov/data-research/research-reports/2020-mortgage-market-activity-and-trends/. The information provided is for purchase loans, so we assumed new homes represented the same percentage of purchase loans as for FHA and VA loans combined.

[8] HUD, "HOME National Production Report – December 31 2021" (2022). https://www.hudexchange.info/programs/home/home-national-production-reports/. Total units completed by fiscal year are allocated by the percentage of total committed units by tenure and activity: We count homebuyer new construction units as single family and rental new construction units as multifamily.

[9] HUD, "RAD Resource Desk: Properties Participating in RAD Program" (2022), www.radresource.net/pha_data.cfm. Number of units for closed PHA projects in new construction column; added the same percentage of RAD for multifamily units, as there is no new construction data for those (adding about a tenth of total units).

[10] HUD, "Public Housing Buildings" (2022), hudgis-hud.opendata.arcgis.com/datasets/HUD::public-housing-buildings/. Number of units with DOFA_ACTUAL_DT (or if absent, CONSTRUCT_DATE) for a given year.

[11] Fannie Mae, "Annual Reports" (2020–2022), www.fanniemae.com/about-us/investor-relations/annual-reports. Used Fannie Mae percentage of all purchase loans, after adjusting for new home purchases without loans in endnote 6.

[12] MBA (Mortgage Bankers Association), "Annual Report on Multifamily Lending" (2019–2021), www.mba.org/news-research-and-resources/research-and-economics/commercial/-multifamily-research/annual-report-on-multifamily-lending?utm_campaign=2020+MF+Lending+Report+8-5-21&utm_medium=email&utm_source=Eloqua, reported in MBA, "Multifamily Lending Hit $359.7

Billion in 2020" (2021), www.mba.org/news-and-research/newsroom/news/2021/08/05/multifamily-lending-hit-359-7-billion-in-2020-x283348.

[13] Freddie Mac, "Annual Report" (2020–2022), www.freddiemac.com/investors/financials/annual-reports. Used Freddie Mac percentage of all purchase loans, after adjusting for new home purchases without loans in endnote 6.

[14] DOE, "Status of State Energy Code Adoption" (2022), www.energycodes.gov/status.

[15] EPA (Environmental Protection Agency), *ENERGY STAR Residential New Construction Program Roadmap* (Washington, DC: EPA, 2021). www.energystar.gov/sites/default/files/asset/document/ENERGY STAR Residential New Construction Program Roadmap.pdf. The energy savings were split into electric and natural gas savings by Dean Gamble (personal communication, February 9, 2022).

[16] S. Nadel, "The Potential for Additional Energy Efficiency Savings Including How the Rebound Effect Could Affect This Potential," *Current Sustainable/Renewable Energy Reports* 3 (1): 35–41 (2016), link.springer.com/article/10.1007/s40518-016-0044-2.

[17] S. Nadel and L. Ungar, *Halfway There: Energy Efficiency Can Cut Energy Use and Greenhouse Gas Emissions in Half by 2050* (Washington, DC: ACEEE, 2019), www.aceee.org/research-report/u1907.

[18] See, e.g., L. Fuchs, L. Skumatz, and J. Ellefsen, "Non-Energy Benefits (NEBs) from ENERGY STAR®: Comprehensive Analysis of Appliance, Outreach, and Homes Programs," *Proceedings of the 2004 ACEEE Summer Study on Energy Efficiency in Buildings* 2: 79–89, www.aceee.org/files/proceedings/2004/data/index.htm, which finds participants value nonenergy benefits as much as energy savings. Also the literature review in S. Pigg, M. Koobeck, L. Nye, S. Stendel, M. Lord, H. McLeod, *Addressing Non-Energy Impacts of Weatherization* (Prepared by Oak Ridge National Laboratory; Washington, DC: DOE, 2021), weatherization.ornl.gov/wp-content/uploads/2021/03/ORNL_SPR-2020_1840.pdf and R. Cluett and J. Amann, *Multiple Benefits of Multifamily Energy Efficiency for Cost-Effectiveness Screening* (Washington, DC: ACEEE, 2015), www.aceee.org/research-report/a1502. However, we assumed that electrification would not reduce nonenergy benefits even if it increased energy bills.

[19] Census Bureau, "2019 American Housing Survey" (2020), www.census.gov/programs-surveys/ahs.

[20] L. Ungar, S. Nadel, and J. Barrett, *Clean Infrastructure: Efficiency Investments for Jobs, Climate, and Consumers* (Washington, DC: ACEEE, 2021), www.aceee.org/white-paper/2021/09/clean-infrastructure-efficiency-investments-jobs-climate-and-consumers.

[21] Census Bureau, "New Residential Sales: Quarterly Sales by Price and Financing, Table Q8" (2022), www.census.gov/construction/nrs/index.html.

[22] See, e.g., A. Brown, A. Soni, M. Lapsa, and K. Southworth, *Low-Income Energy Affordability: Conclusions from a Literature Review* (Washington, DC: DOE, 2020), www.osti.gov/biblio/1607178, and A. Drehobl, L. Ross, and R. Ayala, *How High Are Household Energy Burdens?* (Washington, DC: ACEEE, 2020), www.aceee.org/research-report/u2006.

[23] In American Housing Survey data, 83% of LMI renters of multifamily units built since 2010 pay their own electricity bills, and 77% also pay their own heating bills. In EIA's 2000 Residential Energy Consumption Survey (2022, www.eia.gov/consumption/residential/data/2020/), 71% of households in rented apartments pay all their own energy bills and another 12% pay some of their energy bills.

[24] CO_2 equivalents are from EPA, "Greenhouse Gas Equivalencies Calculator" (2022), www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.

[25] L. Davis and C. Hausman, *Who Will Pay for Legacy Utility Costs?* (Energy Institute at Haas, 2022), haas.berkeley.edu/wp-content/uploads/WP317.pdf.
[26] W. Berg, E. Cooper, and M. DiMascio, *State Energy Efficiency Scorecard: 2021 Progress Report* (Washington, DC: ACEEE, 2022), www.aceee.org/research-report/u2201.
[27] PNNL, "2015 IECC State Cost-Effectiveness Analysis Tool" (2016). V. Salcido, Y. Chen, Y. Xie, and Z. Taylor, *Energy Savings Analysis: 2021 IECC for Residential Buildings* (Prepared by Pacific Northwest National Laboratory; Washington, DC: DOE, 2021), www.energycodes.gov/sites/default/files/2021-07/2021_IECC_Final_Determination_AnalysisTSD.pdf. DOE, *Energy Savings Analysis: 2018 IECC for Residential Buildings* (Washington, DC: DOE, 2019), www.energycodes.gov/sites/default/files/2021-07/EERE-2018-BT-DET-0014-0008.pdf. Z. Taylor, *National Cost Effectiveness of the Residential Provisions of the 2018 IECC* (Prepared by Pacific Northwest National Laboratory; Washington, DC: DOE, 2021), www.energycodes.gov/sites/default/files/2021-07/2018IECC_CE_Residential.pdf.
[28] PNNL, "End Use Data from Performance Indicator Analysis of 90.1-2019" (2021), www.energycodes.gov/sites/default/files/documents/2019EndUseTables.zip. PNNL, "National Cost Effectiveness of Standard 90.1-2019 Workbook" (and for 90.1-2010, 90.1-2013, and 90.1-2016) (2021), www.energycodes.gov/national-and-state-analysis.
[29] DOE, *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Furnaces* (Washington, DC: DOE, 2016), www.regulations.gov/document/EERE-2014-BT-STD-0031-0217. DOE, *Technical Support Document: Energy Efficiency Program for Consumer Products: Residential Central Air Conditioners and Heat Pumps* (Washington, DC: DOE, 2016), www.regulations.gov/document/EERE-2014-BT-STD-0048-0098. DOE, *Preliminary Analysis Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial And Industrial Equipment: Consumer Water Heaters* (Washington, DC: DOE, 2022), www.regulations.gov/document/EERE-2017-BT-STD-0019-0018.