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Energy Impact Study of the 2018 IECC and 2024 IECC Energy Codes for Nebraska

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Executive Summary

The focus of this report is to evaluate the annual residential energy consumption under two energy code conditions. The codes compared are:

- Nebraska's current residential energy code, the 2018 International Energy Conservation Code (IECC), and
- The 2024 International Energy Conservation Code (IECC).

2024 IECC consumes less energy, construction cost payback varies depending on fuel, system type, and location.

The findings of this study indicate that the 2024 International Energy Conservation Code would result in lower energy consumption for homes in all areas of the state. The savings include cooling, heating, lighting, and appliance energy use. The energy savings are largest for homes heated using electric heat pumps.

The largest savings was due to ductwork improvements, most of which are attributable to a new section of the code (Section 408), which allows users of the code to choose from a large menu of options for increased efficiency. Builders must choose at least two different options, worth at least 10 "credits". For the purpose of this analysis, we assumed that most builders would choose to locate at least 80% of ductwork inside conditioned space. We also assumed that those using gas furnaces would choose a high efficiency furnace (95 AFUE) and those using heat pumps would choose to reduce their overall house airtightness to 2.5 ACH50. Many new homes are already built in this way, so in those cases both the associated savings and the construction cost would be neutral. However, for homes that are not already doing this, significant savings can be achieved.

Other changes that contributed to energy savings are increased wall insulation, lower fenestration U-value, improved ventilation system fan efficiency, and an increase to 100% high-efficacy lighting.

The average energy savings was 16.5%, and ranged from 11% to 25% for the various house sizes and locations. The average savings in whole-house energy cost was 12%. Homes using heat pumps averaged 17% cost savings, while homes using gas furnaces averaged 7% cost savings. Depending on house size and location, the savings range from $104 to $906 per year, with an average annual savings of $354.

A cost analysis performed for a median sized house in Omaha showed that overall, the simple payback period for upgrading to the 2024 IECC was approximately 10 years for the home with an electric heat pump and approximately 38 years for the home with a gas furnace. This was in part due to unusually low current gas rates in Omaha. Using the rate paid by residents in other locations in the state, the payback would be about 19 years for the home with a gas furnace.

Using the same example of the median sized home, homeowners with a 30-year mortgage and a heat pump system would pay $103 less per year for combined energy and mortgage payments. The same example with a gas furnace would see homeowners paying a combined $346 per year more for energy and mortgage payments, but this would drop to $190 if gas rates increased to match what ratepayers outside of Omaha are currently paying.

Key differences between 2018 and 2024 codes

Key changes in the 2024 IECC include:

1. Minimum wall R-value has increased. The 2018 IECC required at least R-20 (cavity) or 13+5 (cavity + continuous). The 2024 IECC increases the requirement to at least R-30 cavity, R-20+5 (cavity plus continuous), R-13+10 or R-0+15.
2. The minimum percentage of high-efficacy lighting has increased from 90% to 100%. The definition of "high-efficacy lighting" also changes between the codes. The 2018 definition ranged from >40 to >60 lumens per Watt, depending on the Wattage of the lamp. The 2024 definition is increased to >65 lumens per Watt for all lamps or >45 lumens per Watt for all luminaires. Because the market has largely moved toward LEDs that meet both of these definitions, our modeling was performed using LED lighting for both the 2018 and 2024 cases.
3. The 2024 IECC adds a new section 408 that requires an "additional efficiency package". Users of the prescriptive code must choose from a large menu of options, from which they must earn *at least 10 points using at least 2 different increased efficiency measures*. The measures include things like increasing the overall insulation performance, increased equipment or appliance efficiencies, increased airtightness and decreased duct leakage. For our modeling we used a different set of options for the homes with heat pumps vs furnace/AC.
    a. Heat pump cases – 7 points were obtained by locating 80% of ductwork inside conditioned space (option 408.2.4(3)). An additional 3 points were obtained by improving the home's airtightness from 3.0 ACH50 in the base code to 2.5 ACH50 (option 408.2.1.4).
    b. Furnace/AC cases – As with the heat pump cases, 7 points were earned by locating 80% of the ductwork in side conditioned space. 5 additional points are available for using a gas furnace with at least 95 AFUE efficiency (option R408.2.2(5)). These are already commonly installed in Nebraska and this is actually the efficiency that we use in our base case for both energy codes.
4. The maximum glazing U-factor decreases by a small amount from 0.30 in the 2018 IECC to 0.28 in the 2024 IECC. Neither version of the code places limits on the window solar heat gain coefficient.
5. The 2024 IECC adds new requirements for dimmers and automatic shutoffs on most lighting and exhaust fans.

About the Study

The study considers the annual energy consumption of houses constructed according to the 2018 and 2024 IECC energy codes. Energy use was modeled for three cities selected to represent climate variability in the state: Chadron, Norfolk, and Omaha. Energy modeling was performed using Ekotrope, a commercially available software tool that conforms to RESNET standards[1] for home energy ratings. The RESNET standard is used as the basis for energy-efficient mortgages and is also a primary method used by EPA to determine compliance for the Energy Star® new homes program. It is the most widely accepted means of assessing and comparing home energy performance currently being used in the US.

Four houses were modeled for the study. These include a small ranch style house with 1,453 square feet (sf), a medium ranch style house with 1,852 sf, a medium two-story house with 2,103 sf, and a large two story house at 2,932 sf. Each house was modeled with both 12% and 18% window to wall area ratio. Occupancy and usage patterns were based on national data for average use. Modeling was performed using two different heating/cooling system combinations: (a) a 14.3 SEER2/7.5 HSPF2 heat pump and (b) a 14.3 SEER2 air conditioner with a 95% AFUE gas furnace.

The modeling approach and houses used in this analysis were based on those used for a 2003 study of Nebraska energy codes[2], and follow-up studies performed in 2006, 2009, 2012, 2015, 2018, and 2021 based on updated versions of the IECC[3,4,5,6,7,8,9]. The first study investigated the life cycle cost impacts of upgrading Nebraska's state energy code from the 1983 Model Energy Code to the 2000 IECC. That study concluded that the new energy code would save buyers of new homes between $50 and $295 per year, depending on the size of the house and where they lived. Statewide, the new code was projected to save homeowners $254,000 the first year, and $59.6 million dollars over the life of houses built before 2018. The 2006 study showed that adoption of the 2006 IECC would not save energy compared with the 2003 IECC for the majority of new homes in Nebraska. The 2009 study showed that the 2009 IECC would provide savings, despite some reductions in required envelope insulation. The 2009 IECC was subsequently adopted by the state. The 2012 IECC and 2015 IECC included many of the changes that are in the 2018 IECC, and produced energy savings in heating and lighting, but were not subsequently adopted by the state. The 2018 IECC showed further savings and was subsequently adopted and is the current code in Nebraska. The 2021 IECC showed savings but had a long payback and was not adopted by the state.

About Energy Codes

Energy codes establish minimum insulation requirements for both commercial and residential buildings. Residential codes benefit homeowners by ensuring that newly constructed homes make use of modern techniques and products that make houses energy-efficient. This results in lower energy bills and often improved thermal comfort for the homeowner, and optimal utilization of fossil fuels and nonrenewable resources for communities. Codes also level the playing field for builders by requiring a basic level of quality in areas that homeowners might not see when they are buying a house (for example, the insulation in the walls).

About the Author

Amy Musser holds a Ph.D. degree in Architectural Engineering and an M.S. degree in Mechanical Engineering. She is also a registered professional engineer in the state of Nebraska, and has been conducting research in the fields of building energy and indoor air quality for approximately 30 years. She completed the original Nebraska codes study that investigated the life cycle cost impact of the 2000 IECC for Nebraska while she was a faculty member in the Architectural Engineering Program at the University of Nebraska-Lincoln. She currently holds the position of Principal at Vandemusser Design, LLC, a building energy and air quality consulting firm that she co-founded.

Disclaimer

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Introduction

The objective of this study was to compare the energy impact for Nebraska homeowners under the 2018 International Energy Conservation Code (IECC) and the 2024 IECC. The comparisons were performed with a 14.3 SEER2/7.5 HSPF2 electric heat pump and a 14.3 SEER2 air conditioner with 95% AFUE gas furnace. The study compares the modeled energy use of four houses in three Nebraska climates: Omaha, Norfolk, and Chadron. The four houses are based on those used for previous studies of Nebraska energy codes[2,3,4,5,6,7,8,9]. The houses include a ranch style house at the 20th percentile size being constructed in Nebraska, a ranch style house and a two-story house at the median and average home sizes, and a two-story house at the 80th percentile size. Each house is investigated with both 12% and 18% window to wall area ratio. Occupancy and appliance loads were modeled based on the RESNET standard[1].

Selection and specification of houses modeled

House size and type

The four houses studied were based on those used for a previous study of the life cycle cost impact of adopting the 2000 IECC in Nebraska[2]. A 2002 survey of Nebraska building code officials conducted as part of that study was used as the basis for selecting four homes for modeling. Their square footages represent homes at the 20th percentile, mean, median, and 80th percentile of Nebraska homes. The actual houses modeled, their square footages, and other characteristics are shown in Table 1.

One difference from the original study is that the four houses were modeled with window to wall area ratios of both 12% and 18%. In the original study, the houses were modeled with the actual window area shown on the building plans. The 2006 study[3] was updated to model the homes with window to wall ratios of 12% and 18% due to a code change eliminating more stringent requirements for homes with larger than a 15% window to wall ratio.

House	Plan area	Style	Ceiling height (range, ft)	Above grade exterior wall area (sf)
20th percentile	1,453 sf	ranch	7.5-10.0	1,530
Surveyed mean	1,852 sf	ranch	7.5-10.0	2,000
Midwest mean	2,103 sf	2 story	7.5-9.0	2,620
80th percentile	2,932 sf	2 story	7.5-12.7	2,540

Table 1. Characteristics of houses modeled.

According to the 2002 survey, 92% of Nebraska houses have basements and 26% of these are finished basements. All four houses were modeled with conditioned basements (the square footage in Table 1 does not include the basement square footage). The survey also found that when records on the type of heating and cooling systems installed were available, 67% of new homes had gas-fired forced air furnaces and central air conditioning systems. All four homes were modeled using this type of heating/cooling system for both codes, as well as with an all-electric heat pump system.

Occupant and appliance loads

Occupant behavior and heat gains associated with people and their activities influence the energy required for heating and cooling. The RESNET standard assumes a default lighting and appliance load based on the square footage of the home, as well as typical occupant schedules that affect the consumption of this energy and the internal loads in the home. The number of people living in each home under the standard is the number of bedrooms plus one.

Codes

Two energy code conditions and two heating systems were modeled. The codes were the 2018 IECC (International Energy Conservation Code) and the 2024 IECC. Two heating/cooling systems were modeled for each code: a 14.3 SEER2/7.5 HSPF2 electric heat pump, and a 14.3 SEER2 air conditioner with a 95% AFUE furnace.

Key changes in the 2024 IECC include:

1. Minimum wall R-value has increased. The 2018 IECC required at least R-20 (cavity) or 13+5 (cavity + continuous). The 2024 IECC increases the requirement to at least R-30 cavity, R-20+5 (cavity plus continuous), R-13+10 or R-0+15.
2. The minimum percentage of high-efficacy lighting has increased from 90% to 100%. The definition of "high-efficacy lighting" also changes between the codes. The 2018 definition ranged from >40 to >60 lumens per Watt, depending on the Wattage of the lamp. The 2024 definition is increased to >65 lumens per Watt for all lamps or >45 lumens per Watt for all luminaires. Because the market has largely moved toward LEDs that meet both definitions, our modeling was performed using LED lighting for both the 2018 and 2024 cases.
3. The 2024 IECC adds a new section 408 that requires an "additional efficiency package". Users of the prescriptive code must choose from a large menu of options, from which they must earn at least 10 points using at least 2 different increased efficiency measures. The measures include things like increasing the overall insulation performance, increased equipment or appliance efficiencies, increased airtightness and decreased duct leakage. For our modeling we used a different set of options for the homes with heat pumps vs furnace/AC.
    a. Heat pump cases – 7 points were obtained by locating 80% of ductwork inside conditioned space (option 408.2.4(3)). An additional 3 points were obtained by improving the home's airtightness from 3.0 ACH50 in the base code to 2.5 ACH50 (option 408.2.1.4).
    b. Furnace/AC cases – As with the heat pump cases, 7 points were earned by locating 80k% of the ductwork in side conditioned space. 5 additional points are available for using a gas furnace with at least 95 AFUE efficiency (option R408.2.2(5)). These are already commonly installed in Nebraska and this is actually the efficiency that we use in our base case for both energy codes.
4. The maximum glazing U-factor decreases by a small amount from 0.30 in the 2018 IECC to 0.28 in the 2024 IECC. Neither version of the code places limits on the window solar heat gain coefficient.

The following minor changes are also included in the 2024 IECC:

1. The maximum prescribed U-factor for skylights decreases from 0.55 in 2018 to 0.50 in 2024. None of the homes in this study included skylights, and skylights meeting both versions of the code are widely available in the marketplace.
2. Additional options are added for some components to provide flexibility in using the prescriptive code. For instance, options for continuous insulation in floor and roof assemblies are added. The requirements for cavity insulation that are used in assemblies by most builders remain unchanged.
3. There is a minor change to the code for slabs on grade (not modeled in any of the homes in this study). The requirement for both 2018 and 2024 is R-10, but the length is extended from 2 ft wide to 3 ft wide. In 2018 this insulation was required for slabs within 12" of grade but this has been increased to within 24" of grade for 2024.
4. There are some minor changes related to ductwork. In 2018, supply ducts outside conditioned space required at least R-8 insulation, while return ducts could be insulated to R-6. In 2024, all ducts outside conditioned space require R-8 insulation. Duct testing requirements are essentially unchanged, except that the 2024 IECC requires airtightness testing of ducts located entirely inside conditioned space. The 2024 IECC does include some allowances for higher duct leakage in homes with a larger number of returns, serving small square footage, or ducts entirely in conditioned space. None of these allowances were taken for the modeling in this study. It should also be mentioned here that due to the selection of improved duct leakage in Section 408 (mentioned under "key changes") those specifications were used in modeling for the 2024 cases. Finally, the code adds a requirement for sizing using Manual D.
5. Both the 2018 and 2024 IECC require builders to meet an air sealing checklist (table R402.5.1.1 in the 2024). These are substantially similar with a few changes that primarily offer clarification. The 2021 IECC had introduced a requirement for NEMA OS4 electrical boxes. This has been substantially scaled back and clarified in the 2024 version. The new language includes only "air-sealed…boxes that penetrate the air barrier of the building thermal envelope", which would only apply to exterior outlets and not every outlet located in an exterior wall. This should contribute in a minor way to improved home airtightness, but since the air leakage requirement is 3 ACH50 for both versions of the code, the simulations weren't impacted.
6. There is a new section in 2024 (R403.13) addressing gas fireplaces. Installing a fireplace is optional, and is not part of the energy model that was used for the study. The new requirements have the potential to both save energy and provide indoor air quality benefits. Key new requirements are:
    a. on on-demand pilot or intermittent/interrupted ignition rather than a continuous pilot
    b. minimum efficiency of 50%
    c. vented gas fireplaces must be ANSI listed/labeled.
7. By reference to the IRC or IMC, both the 2018 and 2024 IECC require a whole-house ventilation system using rates specified by ASHRAE Standard 62.2[10]. The ventilation rates required for this standard changed between its 2010 and 2013 (and later) versions. We believe that most in Nebraska are still using the 2010 version, so it was used in all simulations for this report. There is a change in minimum cfm/Watt for ventilation systems. For the 2018 IECC, 1.4 cfm/Watt was required; this increases to 2.8 cfm/Watt in 2024. The 2024 IECC requires

flow rates for whole house ventilation to be measured, a change that is included in the cost section of the report.

8. The 2024 IECC has a new requirement for intermittent exhaust fan controls for toilet rooms and bathrooms. Builders can choose a timer control, occupant sensor, humidity control, or contaminant control. The use of a timer control is included in the cost section of the report. This is more of a health and safety upgrade and is not included in the energy modeling.
9. The 2024 IECC has a new section requiring dimmers or automatic shutoff. All “habitable spaces” are required to have either a dimmer OR an automatic shutoff that shuts off the lights 20 min after occupants leave. Garages, unfinished basements, laundry rooms, and utility rooms require an automatic shutoff that shuts off the lights 20 min after occupants leave. Exterior lighting must have photo-sensor shutoff (for any home with > 30 W total exterior lighting, which would include most homes). As with the treatment of dimmers in previous reports, this is difficult to include in energy modeling since it involves occupant behavior but discussion of the cost and possible benefits in included in the cost section of the report.

Table 2 summarizes the required component values for each of the code conditions. The requirements shown below in Table 2 are associated with the “prescriptive compliance option” of each code, which is the easiest and most often used means of code compliance.

Component	2018 IECC (case a)	2018 IECC (case b)	2024 IECC (case a)	2024 IECC (case b)
	Heat pump	Furnace+AC	Heat pump	Furnace+AC
Glazing U-factor	0.30	0.30	0.28	0.28
Glazing SHGC	none	none	none	none
Opaque door U-factor	0.30	0.30	0.28	0.28
Ceiling R-value (note a)	49	49	49	49
Wall R-value (note b)	20 or 13+5	20 or 13+5	30 or 20+5 or 13+10 or 0+20	30 or 20+5 or 13+10 or 0+20
Floor R-value (notes b, c)	30	30	30 or 19+7.5 or 0+20	30 or 19+7.5 or 0+20
Basement wall R-value (note b)	19 or 0+15	19 or 0+15	19 or 13+5 or 0+15	19 or 13+5 or 0+15
Forced air furnace (AFUE) (note d)	N/A	95%	N/A	95%
Central AC/heat pump (SEER2) (note e)	14.3	14.3	14.3	14.3
Heat pump HSPF2 (note e)	7.5	N/A	7.5	N/A
Programmable thermostat	Yes	Yes	Yes	Yes
% HE lighting (interior)	90	90	100	100
Blower door (ACH50)	3	3	2.5 (note g)	3
Mechanical ventilation cfm/Watt	1.4	1.4	2.8	2.8
Duct insulation R-value (note f)	8/6/6	8/6/6	8/8/6	8/8/6
Duct leakage to outdoors (base code)	2 cfm/100 sf	2 cfm/100 sf	2 cfm/100 sf	2 cfm/100 sf
Modeled duct leakage to outdoors/location (2024 cases - note g)	2 cfm/100 sf (50% Cond. Space)	2 cfm/100 sf (50% Cond. Space)	0.8 cfm/100 sf (80% Cond. Space)	0.8 cfm/100 sf (80% Cond. Space)

Table 2. Component requirements by building code.

Note a: In both codes, R30 may also be used for ceiling areas of up to 20% (max 500 sf) with no attic. Both codes also allow a reduction if uncompressed insulation extends the whole way to the eaves, which was not used in this report.
Note b: The format 13+5 refers to R13 cavity insulation plus R5 continuous insulation.
Note c: Less than R30 may be used if sufficient to fill the framing cavity; with a minimum of R19.
Note d: The current minimum federal efficiency of 80% is required, but 95% is widely installed, will be the federal minimum in 2028, and was used for the analysis.
Note e: The national energy efficiency standard for residential heat pumps manufactured after 2023.
Note f: The format 8/6/6 refers to R-8 supply ducts in attics, R-6 for return ducts in attics, and R-6 for ducts in the conditioned envelope.
Note g: These specifications are improved beyond the prescriptive track to meet section 408.

Neither of the codes modeled places a limit on window to wall ratio. Both codes also allow lower R values to be used for ceilings and floors if the insulation fills the framing cavity. In this analysis, we assumed that the builder did *not* make use of this exemption for floors. The exception was allowed for a small section of vaulted ceiling (5% of the total roof area) in the largest of the home plans, where a vaulted ceiling was modeled as R-30 for both codes.

The houses in this study had only small areas of framed insulated floor, which was limited primarily to framed floors over garages. Modeling was performed with basement insulation in cavity walls, with R-19 used for both codes.

The 2024 code does have minor changes to on-grade slab insulation (a change from 2 ft to 4 ft required) and crawlspace wall insulation (an additional compliance option was added). These conditions don't impact the models in this study since neither envelope component is present in these homes.

Climates

Three cities were chosen to represent the climate variation in Nebraska. The National Oceanic and Atmospheric Administration (NOAA) publishes a list of annual degree days that includes approximately 140 cities and towns in the state of Nebraska. The heating degree days (65°F base) in the state range from 5,552 to 7,862. Table 3 summarizes the selected cities and their actual numbers of degree days. Numbers of degree days for other code jurisdictions not shown can be found in Table A1 in the appendix to this report. Note that the state's second largest city, Lincoln, has nearly the same climate as Omaha (6,119 vs. 6,153 heating degree days).

City	Annual heating degree days	Annual cooling degree days
Omaha	6,153	1019
Norfolk	6,766	939
Chadron	7,021	770

Table 3. Selected Nebraska cities and climates.

The climate zone map for Nebraska is unchanged between the 2018 and 2024 IECC, both of which place the entire state of Nebraska in a single climate zone (5). Variations in actual heating degree days and cooling degree hours throughout the state will cause different cities to respond to code changes in slightly different ways.

Component Selection

Since variations in the way that some components are selected and installed can impact thermal performance, and because certain products are available only in discrete increments of R-value, it was necessary to specify some components in detail.

Windows

All code conditions are modeled with a window having exactly the prescribed U-factor.

Although neither code places limits on the SHGC (solar heat gain factor), this specification can significantly impact energy results. From a practical standpoint the methods used to achieve the U-values prescribed by the code tend to also lower the SHGC and glazing products that are widely installed tend to have lower SHGC values than in the past. For both codes in this analysis, an SHGC of 0.33 was used.

This SHGC was derived from a review of available residential glass types from Cardinal, one of the major providers of glass for windows manufactured in the US. Of the glass types that could achieve the code-required U-value when installed in an assembly, the highest SHGC among non-specialty widely used options was 0.41 (low-e 272 glass). When testing is performed on an assembly, the assembly SHGC is typically about 80% of the glass SHGC (to allow for frame effects), which produces an SHGC of 0.33.

Windows were modeled at 12% or 18% window to wall ratio, with 25% of the window area placed in each compass direction (N, S, E, and W) and no overhang.

Exterior wall insulation

In the model, the R-value of cavity insulation is adjusted to account for the effects of wood studs and other framing members. For this analysis, a framing factor of 0.23 was used; this means that the wood construction makes up 23% of the wall surface area.

The 2018 IECC requires R-20 cavity insulation or R-13 cavity insulation with R-5 rigid insulation on the exterior. Typically, fiberglass batts are currently available in R-19 and R-21 increments. Cellulose insulation is typically R-21 when used in a 2x6 wall, and spray foams are now available that can be applied in various thicknesses to achieve R-values of 20 or more in a 2x6 cavity. Based on the code requirement for R-20, it is likely that most 2x6 walls will actually have installed R-21 cavity insulation. The overall U-factor for this assembly is 0.058. The U-factor for an assembly with exactly R-20 cavity insulation is 0.060. If the 13+5 method is used, a 2x4 stud wall with R-5 exterior insulation achieves a U-value of 0.058. However, accounting for sheathing on 25% of the exterior, the resulting U-value is 0.060. Because all of these scenarios are very close to one another, the 2018 IECC was modeled with an R-20 cavity insulation in a 2x6 wall, with an overall U-value of 0.60.

The increased wall insulation for the 2024 IECC has many options. The cavity-only option of R-30 does not line up well with traditionally available wall framing methods and available batt thicknesses, so we believe most builders would choose to use the R-13+10 option. This would be done using a 2x4 wall with R-10 exterior insulation and an R-13 fiberglass batt in the framed cavity. The U-factor for this combination is 0.041.

Basement wall insulation

This analysis was performed with the assumption that the basements are conditioned, which requires that basement walls be insulated. For all of the code conditions, R-19 insulation was placed in a 2x6 framed cavity on the interior of the basement wall. Framing was modeled as 16” o.c. wood framing.

Ceiling insulation

Most of the ceiling area for the four house plans is beneath attics. Where attics are present, blown-in fiberglass insulation is used in the correct thickness to meet the R-value requirement. Framing is modeled with a 2x12 structural member at the attic floor and an 11% framing factor.

The largest floor plan also contains a small amount of cathedral ceiling (about 5% of the overall roof area) directly beneath a sloped roof supported by 2x10 joists. R-30 fiberglass batts were used in these locations. Table 4 summarizes the roof/ceiling insulation combinations that were used to meet the codes.

R-value (°Fft^{2}hr/Btu)	Insulation location	Insulation type
30	Cathedral ceiling	9" R30 fiberglass batts
49	Attic floor	19.6" blown-in fiberglass insulation (R2.5 per inch)

Table 4. Roof and ceiling insulation combinations used to meet code requirements.

Floor insulation

Insulation requirements for framed floors over unconditioned space were met using an R-30 fiberglass batt in a minimum 2x10 floor cavity, with a framing factor of 13%. Note that if the depth of floor insulation is less than that of the framing cavity, the insulation must be installed next to the floor above in order to function properly.

Exterior doors

The U-factor requirement for opaque doors is equal to the U-factor requirement for windows under both codes, and the opaque portions of doors were modeled having this specified U-factor. The requirement for a 0.30 or lower U-factor will likely require that a fiberglass or metal insulated door be used. These typically achieve U-factors of 0.20 or better and would meet either the 2018 or 2024 IECC.

Infiltration

Both the 2018 and 2024 IECC require airtightness testing with a blower door, and homes must achieve the stringent requirement of 3 ACH50 or less. Both also have an air sealing checklist that is substantially unchanged in 2024. Modeling was done with this tested air leakage.

Whole-house ventilation

The 2018 and 2024 IECC refer to the IRC or IMC (specified without date). These both require a system using the flow rates specified by ASHRAE Standard 62.2 (assumed 2010 version)[10].

All cases were modeled with whole-house ventilation systems. The rate is based on finished floor area and number of bedrooms. To calculate the rate for each of the modeled homes, 50% of the basement floor area was assumed to be finished, and there were no bedrooms in the basement. The whole-house mechanical ventilation systems were assumed to be continuously operating exhaust-only. For the 2018 IECC cases, the fan efficiency is 1.4 cfm/Watt. Fan efficiency increases to 2.8 cfm/Watt for the 2024 IECC. Table 5 shows the ventilation flow rates and fan Watts modeled for each home in the study.

Main floor area (sf)	# of bedrooms	Whole house ventilation airflow (cfm)	Fan power (W) 2018 IECC	Fan power (W) 2024 IECC
1453	3	52	37	19
1852	3	58	41	21
2103	4	69	49	25
2932	4	82	59	29

Table 5. Whole house ventilation inputs.

Thermostat settings

The RESNET standard was used to determine thermostat setpoints (68°F winter/78°F summer) and energy savings associated with the programmable thermostat.

Ducts

Ducts for the 2018 IECC cases were modeled with an R-value of 8 for supply ducts outside conditioned space and an R-value of 6 for all other ducts. The homes were modeled so that each has 50% of its ducts located in attics and/or floors over garages as appropriate to each home's design.

The 2018 cases were modeled with 2 cfm/100 sf duct leakage to outdoors (often referred to as 2% duct leakage). 2% was chosen because many homes in Nebraska have some or all of their duct systems located inside conditioned space. For this reason, we felt that even though the maximum duct leakage allowed by the code is 4% to the outdoors, many homes in the state will actually test better as a result of the requirement. We also felt that the requirement would create incentive for builders to place ducts inside conditioned space. Thus, 2% leakage to the outside is a better estimate of the actual condition likely to be present under the 2018 IECC and is consistent with how modeling was performed in our previous reports.

The 2024 IECC cases were modeled with the air handler and 80% of ducts located inside conditioned space, based on our selection of options in the new Section 408 (additional efficiency packages). We chose to select this option because we felt that it was one of the lower-cost and most straightforward options available and would therefore be a popular choice with builders. Since only 20% of ducts are located outside conditioned space, these cases were modeled with 0.8 cfm/100 sf duct leakage to outdoors, a proportional reduction from the 4% total duct leakage allowed.

All ducts (supply and return) located outside conditioned space were modeled as having R-8 insulation under the 2024 IECC. Ductwork located outside of conditioned space was modeled as being located in the vented attic.

HVAC system sizing

HVAC system sizing can affect the simulated energy consumption of a home. Oversized cooling systems can be penalized for short-cycling inefficiencies and this short-cycling can also cause inadequate dehumidification to occur. Heat pumps sizing is typically limited by the cooling load which can cause less efficient strip heating to be used in very cold weather. Both version of the code require that HVAC contractors utilize a Manual J calculation (or approved alternative) to size heating and cooling equipment. This ensures that the installed equipment will have enough capacity to meet the cooling load, but it is also important to avoid oversizing because short cycling of conditioning equipment can be inefficient and provides inadequate dehumidification in the summer. Another benefit of properly sizing equipment is that homeowners may see a cost savings if the increased insulation and airtightness requirements of the new code allow smaller equipment to be installed.

All air conditioners and heat pumps were sized in ½ ton increments. Air conditioners and heat pumps were sized using Manual S "condition A", which requires that single stage compressors be sized between 90-130% of the Manual J load calculation. For the simulations, the largest ½ ton increment size that fell within 100-130% of the total cooling load was used.

Lighting

The Ekotrope software allows lighting to be modeled as a defined percentage of incandescent, fluorescent, and LED lamps. All high efficacy lighting for both codes was modeled as LED, since the market has substantially moved in that direction. The 2018 IECC was modeled with 90% LED lamps and 10% incandescent lamps for indoors. The 2024 IECC was modeled with 100% LED lamps indoors. The model also allows lighting type to be specified for outdoor and garage lighting. Since both codes are silent on outdoor/garage lighting, these were modeled as incandescent to allow future simulations to accommodate an upgrade to LED if this occurs.

Water heating

Both codes were modeled with R-3 pipe insulation and standard-efficiency fixtures. Both code conditions were modeled with a 50 gallon electric water heater having an efficiency factor of 0.92, a DOE rated capacity of 46 gallons and located inside conditioned space. Recirculation systems and domestic hot water heat recovery were not used. The distance from the water heater to the furthest fixture was set to software default length, which is based on the size of the home.

Results

Annual energy simulations were performed for the four houses under the four code and HVAC conditions to determine their annual energy consumption. Comparison of the results shows that the 2024 IECC requires less overall energy than the 2018 cases for all houses and climates. All of the homes showed savings. The savings were larger for the homes heated with heat pumps.

Energy use

Table 6 shows the annual cooling-related electricity consumption of each house under each code condition. The furnace efficiency does not impact cooling energy, so the (a – heat pump) and (b – furnace/air conditioner) cases of each code are identical for the 2018 IECC. The small difference between heat pumps and furnace/air conditioners with the 2024 IECC occurs because the modeled infiltration is 3 ACH50 for the furnace cases vs. 2.5 ACH50 for the heat pump cases. Cooling savings are substantial and are mostly due to the duct improvements, which include a reduction in leakage to outdoors (from 2 cfm25/sf to 0.8 cfm25/sf), increasing return duct R-value from 6 to 8, and increasing the percentage of ductwork inside conditioned space (from 50% to 80%). The percent savings ranged from 11 to 17%, with an average of 13.6%.

To show the impact of each change on cooling, a step-wise analysis was performed using the 1852 sf home in Omaha with 18% glazing. The first 5 steps are the same for both the gas furnace and heat pump cases. The final step, improving the whole-house airtightness, only applies to the heat pump case. This shows that in addition to the larger savings from the ductwork changes, there are also moderate savings related to the increase in high-efficacy lighting and the increased wall insulation. The savings related to increased insulation are small. The change in ventilation system cfm/Watt is assigned to appliance energy savings and doesn't impact heating or cooling since there is no heat recovery and the volume of ventilation air stays the same. Note that the incremental change in energy use for each item is dependent on the order in which the items are added, but the process is a helpful way to demonstrate the effects of each change.

Code-based change	Cooling kWh	Change (kWh)
Begin with 2018 IECC	2173.0	
Decrease window U-value to 0.28	2177.2	+4.2
Increase wall insulation from R-19 to R13+10	2139.1	-38.1
Duct improvements	1932.0	-207.1
Increase ventilation cfm/Watt to 2.8	1932.0	-0
Increase to 100% high-efficacy lighting	1888.1	-43.9
Increase airtightness from 3.0 to 2.5 ACH50	1872.6	-15.5
End with 2024 IECC	1872.6	-300.4 (total change)

Code	City	Window/ wall ratio	1,453 sf ranch	1,852 sf ranch	2,103 sf 2 story	2,932 sf 2 story
2018 IECC (a)	Omaha	12%	1494	1820.9	2130.3	2843.5
2018 IECC (b)	Omaha	12%	1494	1820.9	2130.3	2843.5
2024 IECC (a)	Omaha	12%	1294.4	1555.3	1847.7	2362.3
2024 IECC (b)	Omaha	12%	1304.8	1570	1861.1	2383.3
2018 IECC (a)	Omaha	18%	1771	2173	2565.8	3357.1
2018 IECC (b)	Omaha	18%	1771	2173	2565.8	3357.1
2024 IECC (a)	Omaha	18%	1549.5	1872.6	2257.2	2878.3
2024 IECC (b)	Omaha	18%	1560.6	1888.1	2271.8	2905.5
2018 IECC (a)	Norfolk	12%	1034	1273.1	1571.2	2048.1
2018 IECC (b)	Norfolk	12%	1032.8	1273.1	1571.2	2048.1
2024 IECC (a)	Norfolk	12%	891.9	1083	1366.9	1700.9
2024 IECC (b)	Norfolk	12%	895.6	1088.7	1369.3	1706.4
2018 IECC (a)	Norfolk	18%	1278.6	1593.6	1981.3	2519.6
2018 IECC (b)	Norfolk	18%	1278.6	1593.6	1981.3	2519.6
2024 IECC (a)	Norfolk	18%	1129.5	1377.5	1754.4	2173.3
2024 IECC (b)	Norfolk	18%	1132.7	1380.9	1756	2178.4
2018 IECC (a)	Chadron	12%	784.8	965.1	1211.5	1557.1
2018 IECC (b)	Chadron	12%	784.8	965.1	1211.5	1557.1
2024 IECC (a)	Chadron	12%	679.6	825.9	1052.8	1298.9
2024 IECC (b)	Chadron	12%	678.5	824.8	1049.9	1297.4
2018 IECC (a)	Chadron	18%	987.7	1229.8	1562.8	1955.2
2018 IECC (b)	Chadron	18%	987.7	1229.8	1562.8	1955.4
2024 IECC (a)	Chadron	18%	876.5	1069.4	1389.4	1693.8
2024 IECC (b)	Chadron	18%	873.8	1066.5	1383.7	1688.6

Table 6. Annual cooling electricity consumption (kWh).

For the cases (a) using heat pumps, the heating electricity use for the 2024 IECC ranged from 27 to 38% lower than the 2018 IECC, with an average savings of 33%. The percent savings were relatively consistent between the home sizes, cities, and percent glazing. The heating electricity consumption using gas furnaces is small and related to operation of the system fan.

Code	City	Window/ wall ratio	1,453 sf ranch	1,852 sf ranch	2,103 sf 2 story	2,932 sf 2 story
2018 IECC (a)	Omaha	12%	11469.9	13923.3	14443.9	23371.6
2018 IECC (b)	Omaha	12%	551.7	674.8	704.8	1072.4
2024 IECC (a)	Omaha	12%	7268.8	9642.9	10000.8	15993.7
2024 IECC (b)	Omaha	12%	460.2	568.4	586	896
2018 IECC (a)	Omaha	18%	12163	14778.5	13968.9	22998.3
2018 IECC (b)	Omaha	18%	573.3	701.5	739.6	1115.3
2024 IECC (a)	Omaha	18%	7732.3	9260.9	9797.3	15716.9
2024 IECC (b)	Omaha	18%	416.8	586.8	612.1	924
2018 IECC (a)	Norfolk	12%	15448.6	18903.5	19253.3	31705.8
2018 IECC (b)	Norfolk	12%	684.8	839.7	864.5	1326
2024 IECC (a)	Norfolk	12%	9802	12936.6	13214.7	21314.6
2024 IECC (b)	Norfolk	12%	572.3	707.7	719.9	1107.8
2018 IECC (a)	Norfolk	18%	14164.7	19907.1	18594.1	31151.8
2018 IECC (b)	Norfolk	18%	690.8	869	903.1	1373.3
2024 IECC (a)	Norfolk	18%	10338.5	12463.2	12951.6	20915.9
2024 IECC (b)	Norfolk	18%	589.5	726.9	747.9	1136.3
2018 IECC (a)	Chadron	12%	11608.4	14056	14477.1	23416.8
2018 IECC (b)	Chadron	12%	581.5	709.2	732.4	1118.4
2024 IECC (a)	Chadron	12%	7350.3	9550	9141	14538.6
2024 IECC (b)	Chadron	12%	481.9	593.9	604.1	927.8
2018 IECC (a)	Chadron	18%	10672.3	14870.6	14088.6	23017.4
2018 IECC (b)	Chadron	18%	599.8	731.8	764	1154.1
2024 IECC (a)	Chadron	18%	7732.1	9330.4	9755.6	14694.8
2024 IECC (b)	Chadron	18%	496.8	612.6	626.7	958.1

Table 7. Annual heating electricity consumption (kWh).

Table 8 shows gas consumption for the various cases in therms per year. In all cases, the 2024 IECC has lower gas consumption. The reduction in gas consumed (for the homes using gas furnaces) ranged from 14.7% to 18%, with an average of 16.7%. The percent heating savings in the homes with gas furnaces is lower than in the heat pump cases in part because these homes did not have savings related to reducing whole-house airtightness to meet section 408. Another factor is that the heat pumps were sized using manual S and typically the cooling load was less than the heating load, so the cold-weather energy savings reduced inefficient backup strip heating for those homes.

The step-wise calculation (again using the 1852 sf Omaha house with 18% glazing, both gas furnaces and electric heat pump cases are provided) shows that all of the code changes in the 2024 IECC reduce heating energy use except the increase to 100% LED lighting. This increases heating energy use because it decreases the internal heat gain from the lighting, but it does provide savings in both cooling and appliance energy and overall it is an energy saving measure. The duct improvements produce the largest increase in heating energy use. Smaller but still significant savings are attributed to wall insulation, increased house airtightness (for the heat pump case) and window U-value.

Code	City	Window/ wall ratio	1,453 sf ranch	1,852 sf ranch	2,103 sf 2 story	2,932 sf 2 story
2018 IECC (a)	Omaha	12%	0	0	0	0
2018 IECC (b)	Omaha	12%	480.8	588.1	614.2	934.6
2024 IECC (a)	Omaha	12%	0	0	0	0
2024 IECC (b)	Omaha	12%	401	495.3	510.7	780.9
2018 IECC (a)	Omaha	18%	0	0	0	0
2018 IECC (b)	Omaha	18%	499.7	611.3	644.5	972
2024 IECC (a)	Omaha	18%	0	0	0	0
2024 IECC (b)	Omaha	18%	416.8	511.4	533.5	805.3
2018 IECC (a)	Norfolk	12%	0	0	0	0
2018 IECC (b)	Norfolk	12%	596.8	731.8	753.4	1155.6
2024 IECC (a)	Norfolk	12%	0	0	0	0
2024 IECC (b)	Norfolk	12%	498.7	616.8	627.4	965.5
2018 IECC (a)	Norfolk	18%	0	0	0	0
2018 IECC (b)	Norfolk	18%	602.1	757.3	787.1	1196.8
2024 IECC (a)	Norfolk	18%	0	0	0	0
2024 IECC (b)	Norfolk	18%	513.7	633.5	651.8	990.3
2018 IECC (a)	Chadron	12%	0	0	0	0
2018 IECC (b)	Chadron	12%	506.7	618.1	638.3	974.7
2024 IECC (a)	Chadron	12%	0	0	0	0
2024 IECC (b)	Chadron	12%	420	517.6	526.5	808.6
2018 IECC (a)	Chadron	18%	0	0	0	0
2018 IECC (b)	Chadron	18%	522.7	637.8	665.8	1005.8
2024 IECC (a)	Chadron	18%	0	0	0	0
2024 IECC (b)	Chadron	18%	433	533.9	546.1	835

Table 8. Annual heating gas consumption (therm).

Code-based change (gas furnace case)	Heating Therms	Change (Therms)
Begin with 2018 IECC	611.3	
Decrease window U-value to 0.28	596.4	-14.9
Increase wall insulation from R-19 to R13+10	556.5	-39.9
Duct improvements	505.9	-50.6
Increase ventilation cfm/Watt to 2.8	505.9	-0
Increase to 100% high-efficacy lighting	511.4	+5.2
End with 2024 IECC	511.4	-99.9 (total change)

Code-based change (heat pump case)	Heating kWh	Change (kWh)
Begin with 2018 IECC	14778.5	
Decrease window U-value to 0.28	14343.6	-434.9
Increase wall insulation from R-19 to R13+10	13174.8	-1168.8
Duct improvements	9726.2	-3448.6
Increase ventilation cfm/Watt to 2.8	9726.2	-0
Increase to 100% high-efficacy lighting	9836.8	+110.60
Increase airtightness from 3.0 to 2.5 ACH50	9260.9	-575.90
End with 2024 IECC	9260.9	-5517.60 (total)

Table 9 shows the annual electricity consumption for lighting and appliances. Since this does not depend on city or glazing percentage, it is simply shown for each code and each house size. This value is influenced by the change to 100% high-efficacy lamps and the improved efficiency of the mechanical ventilation fan. Overall, the average savings in lighting/appliance energy was 5.8%.

Code	1,453 sf ranch	1,852 sf ranch	2,103 sf 2 story	2,932 sf 2 story
2018 IECC	6998.8	8004.3	7808.6	10428.3
2024 IECC	6612	7549.8	7346.5	9786.8

Table 9. Annual electricity consumption for lights and appliances (kWh)

Table 10 shows annual whole-house energy consumption in MMBtu/year. This includes heating and cooling, domestic water heating, and lights and appliances. In all cases, the 2024 IECC used less total energy than the 2018 IECC. The percent savings are larger for homes that are heated using heat pumps. The savings range from 10.7% (the 2932 sf house with 12% glazing and gas furnace in Norfolk) to 24.8% (the 2932 sf house with 12% glazing and electric heating in Chadron). The average overall energy savings for all cases was 16.5%. The average savings for homes with gas furnaces was 12.2%, while the average savings for homes with heat pumps was 20.8%.

Code	City	Window/ wall ratio	1,453 sf ranch	1,852 sf ranch	2,103 sf 2 story	2,932 sf 2 story
2018 IECC (a)	Omaha	12%	79.03	91.95	96.09	137.94
2018 IECC (b)	Omaha	12%	89.85	105.54	110.62	155.29
2024 IECC (a)	Omaha	12%	62.69	74.88	78.39	108.93
2024 IECC (b)	Omaha	12%	79.59	93.5	97.37	135.56
2018 IECC (a)	Omaha	18%	82.34	96.07	95.96	138.42
2018 IECC (b)	Omaha	18%	92.75	109.16	115.26	160.93
2024 IECC (a)	Omaha	18%	65.14	74.66	79.09	109.74
2024 IECC (b)	Omaha	18%	82.1	96.25	101.13	139.87
2018 IECC (a)	Norfolk	12%	91.74	107.78	111.44	164.51
2018 IECC (b)	Norfolk	12%	101.03	119.31	124.02	176.38
2024 IECC (a)	Norfolk	12%	70.66	85.21	88.55	125.67
2024 IECC (b)	Norfolk	12%	89.05	105.17	108.65	153.27
2018 IECC (a)	Norfolk	18%	88.19	112.3	110.59	164.22
2018 IECC (b)	Norfolk	18%	102.41	123.05	128.92	182.28
2024 IECC (a)	Norfolk	18%	73.3	84.6	88.98	125.92
2024 IECC (b)	Norfolk	18%	91.41	107.91	112.51	157.46
2018 IECC (a)	Chadron	12%	77.71	90.11	93.82	134.45
2018 IECC (b)	Chadron	12%	90.75	106.36	110.73	155.82
2024 IECC (a)	Chadron	12%	61.49	72.7	73.48	101.08
2024 IECC (b)	Chadron	12%	80.04	93.89	96.99	135.48
2018 IECC (a)	Chadron	18%	75.2	93.79	93.69	134.44
2018 IECC (b)	Chadron	18%	93.1	109.31	114.79	160.4
2024 IECC (a)	Chadron	18%	63.47	72.78	76.73	102.96
2024 IECC (b)	Chadron	18%	82.06	96.41	100.17	139.56

Table 10. Annual whole house energy consumption (MMBtu/year).

To understand the relative impact of each change on the overall energy use in Table 10, the Omaha 18% glass, 1852 sf home was again used (both the gas heating and heat pump cases are shown). This house design had a reduction in total energy use of 11.8% for the gas furnace case and 22.3% for the heat pump case.

Code based change (gas furnace case)	Energy use MMBtu/yr	Change (MMBtu/year)
Begin with 2018 IECC	109.1	
Decrease window U-value to 0.28	107.6	-1.5
Increase wall insulation from R-19 to R13+10	103.3	-4.3
Duct improvements	97.4	-5.9
Increase ventilation cfm/Watt to 2.8	96.7	-0.7
Increase to 100% high-efficacy lighting	96.2	-0.5
End with 2024 IECC	96.2	-12.9 (total change)

Code based change (heat pump case)	Energy use MMBtu/yr	Change (MMBtu/year)
Begin with 2018 IECC	96.0	
Decrease window U-value to 0.28	94.6	-1.4
Increase wall insulation from R-19 to R13+10	90.5	-4.1
Duct improvements	78.0	-12.5
Increase ventilation cfm/Watt to 2.8	77.4	-0.6
Increase to 100% high-efficacy lighting	76.7	-0.7
Increase airtightness from 3.0 to 2.5 ACH50	74.6	-2.1
End with 2024 IECC	74.6	-21.4

The order in which the changes are implemented in the above analysis does slightly impact the magnitude of each change. As was seen with both heating and cooling energy individually, the largest whole-house energy reduction is obtained from the duct improvements. The magnitude of this change is larger for the heat pump homes. This happens because the heat pumps are sized using Manual S and the peak heating load for all of the homes was larger than the peak cooling load. As a consequence, the heat pumps will have longer heating runtimes (and thus experience more duct leakage) and also use less efficient strip heat during the coldest weather conditions.

The next largest savings is due to the increased wall insulation. All of the other code changes produce savings but of a smaller magnitude. The heat pump cases also benefit from additional energy savings related to increasing the house airtightness.

Table 11 shows energy cost in dollars per year for each of the cases. Adopting the 2024 IECC saves consumers between 5% and 22% depending on the city and the fuel used. The average is 12% savings. The percent savings in energy cost and energy consumption are not exactly the same because different fuels (gas and electricity) have different costs and because each fuel has a fixed customer charge. Depending on house size and location, the savings range from $104 to $906 per year, with an average annual savings of $354.

Code	City	Window/ wall ratio	1,453 sf ranch	1,852 sf ranch	2,103 sf 2 story	2,932 sf 2 story
2018 IECC (a)	Omaha	12%	2637	3001	3121	4288
2018 IECC (b)	Omaha	12%	2057	2252	2338	2852
2024 IECC (a)	Omaha	12%	2188	2531	2633	3489
2024 IECC (b)	Omaha	12%	1953	2128	2206	2654
2018 IECC (a)	Omaha	18%	2732	3120	3126	4311
2018 IECC (b)	Omaha	18%	2098	2304	2402	2929
2024 IECC (a)	Omaha	18%	2260	2531	2660	3521
2024 IECC (b)	Omaha	18%	1991	2173	2264	2725
2018 IECC (a)	Norfolk	12%	2524	2907	2999	4252
2018 IECC (b)	Norfolk	12%	2124	2362	2447	3103
2024 IECC (a)	Norfolk	12%	2033	2380	2465	3346
2024 IECC (b)	Norfolk	12%	1984	2196	2268	2833
2018 IECC (a)	Norfolk	18%	2448	3017	2988	4255
2018 IECC (b)	Norfolk	18%	2153	2418	2519	3188
2024 IECC (a)	Norfolk	18%	2099	2791	2483	3362
2024 IECC (b)	Norfolk	18%	2021	2240	2329	2903
2018 IECC (a)	Chadron	12%	2200	2499	2593	3560
2018 IECC (b)	Chadron	12%	2019	2231	2311	2891
2024 IECC (a)	Chadron	12%	1821	2090	2117	2779
2024 IECC (b)	Chadron	12%	1891	2081	2147	2652
2018 IECC (a)	Chadron	18%	2148	2590	2599	3570
2018 IECC (b)	Chadron	18%	2054	2276	2372	2961
2024 IECC (a)	Chadron	18%	1871	2098	2199	2831
2024 IECC (b)	Chadron	18%	1923	2120	2199	2716

Table 11. Annual whole house energy cost ($/year).

Conclusions

The findings of this study indicate that the 2024 International Energy Conservation Code would result in less energy consumption for homes in all areas of the state. Duct improvements make the largest contribution to the savings. Improvements to fenestration U-value, wall insulation, ventilation system efficiency, an increase to 100% LED lighting, and improved airtightness (where used to meet the new section 408) also contributed to savings.

The average energy savings was 16.5%, and ranged from 10.7% to 24.8% for the various house sizes and locations. The average savings in whole-house energy cost was 6.8% for homes using gas furnaces and 17.3% for homes using electric heat pumps. Depending on house size and location, the savings range from $104 to $906 per year, with an average annual savings of $354.

Cost analysis

This section discusses construction cost impacts associated with upgrading the Nebraska State Energy Code from the current 2018 International Energy Conservation Code (IECC) to the 2024 IECC. The item-by-item differences between the 2018 and 2024 codes and the cost impact of each are discussed below.

Cost data

Cost estimates and other referenced data were obtained from these sources:

- *Residential Costs with RS Means data– 2025*, 44th annual edition; Gordian. (Costs from Means are based on Omaha as a location. The cost factors for other locations in the state are lower than Omaha. Unless noted otherwise, costs obtained from RS Means include materials, labor, equipment, overhead and profit to represent what an installing contractor will charge a customer.)
- *EPA report: "Cost & Savings estimates: Energy Star Certified Homes, Version 3.1 (Rev. 09)* Dec. 20, 2018 available online at: https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Version%203.1%20Cost%20%20Savings%20Summary.pdf. This report provides an estimate of the incremental cost to build an Energy Star version 3 certified home compared to the 2012 IECC code.
- *EPA report: "Cost & Savings estimates: Energy Star Single Family New Homes, Version 3.2 (Rev. 12)* Jan. 1, 2023 available online at: https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Version%203.2%20Cost%20%20Savings%20Summary.pdf. This report provides an estimate of the incremental cost to build an Energy Star version 3 certified home compared to the 2021 IECC code. Being newer than the previous report, it was used unless information was needed that wasn't included in this report.
- Energy Star Windows, Doors, and Skylights Version 7.0 Criteria Analyis Report July 2021 available online and accessed on 2/15/25 at: ES_Residential_WDS_Draft 1_Criteria Analysis Report.pdf
- *Home Depot web site* – provides online pricing available to customers nationwide. Online pricing often mirrors pricing available in national chain home improvement stores. Pricing for this report was obtained using an Omaha zip code as the store location, in February 2025.
- *Rexell USA (a national supply house for electrical contractor, at https://rexellusa.com)*: Pricing for this report was obtained in February 2025. This source was used to obtain pricing for airtight and regular electrical boxes, as well as dimmer and timer switches.
- *HVI directory online*: https://www.hvi.org/hvi-certified-products-directory/
- *CPI inflation calculator:* This online calculator was used to adjust costs that were derived from sources older than 1 year where comparable newer data were not readily available. Found online at www.bls.gov
- *NREL National Residential Efficiency Measures Database: https://remdb.nrel.gov/* The National Residential Efficiency Measures Database is a publicly available, centralized resource of residential building retrofit measures and costs for the U.S. building industry. Accessed February 2025.
- *Fireplaces Direct website (a national online sales source for fireplaces online at https://fireplacesdirect.com):* Pricing for this report was obtained in February 2025.

Cost and savings examples are shown for the 1852 sf three-bedroom home with 18% window to wall ratio located in Omaha. Since there are different measures for the home with heat pump and gas furnace, both are shown. This is the median sized home plan in the study. The energy cost savings by line item for this house are as shown below:

Heat pump case

Code based change	Energy cost $/yr	Change ($/year)
Begin with 2018 IECC	3120	
Decrease fenestration U-value to 0.28	3080	-40
Increase wall insulation from R-19 to R13+10	2968	-112
Increase ventilation cfm/Watt to 2.8	2950	-18
Increase to 100% high-efficacy lighting	2931	-19
Move 80% of ducts into conditioned space	2587	-344
R-8 ductwork in attic	2586	-1
Improve airtightness to 2.5 ACH50	2531	-55
Change in heat pump size: none		-0
End with 2024 IECC	2531	-589 (total change)

Gas furnace case

Code based change	Energy cost $/yr	Change ($/year)
Begin with 2018 IECC	2304	
Decrease fenestration U-value to 0.28	2296	-8
Increase wall insulation from R-19 to R13+10	2271	-25
Increase ventilation cfm/Watt to 2.8	2253	-18
Increase to 100% high-efficacy lighting	2223	-30
Move 80% of ducts into conditioned space	2174	-49
R-8 ductwork in attic	2173	-1
Change in heat pump size: none		-0
End with 2024 IECC	2173	-131 (total change)

In addition, there are some changes in the 2024 IECC that don't directly correlate to a modeled energy savings that are included in the cost report. These include: (1) ventilation fans are required to be tested and meet the specified airflow, (2) NEMA OS4 electrical boxes are required for electrical and boxes that penetrate the exterior air barrier, (3) dimmer and timer switches for most lighting fixtures and exhaust fans, and (4) additional fireplace requirements. The use of a 95 AFUE furnace to meet section 408 (furnace case only) is treated as both energy and cost neutral since these are commonly installed in Nebraska and have been used as a base case for previous versions of this report.

Sometimes the implementation of energy efficiency measures results in a change in heat pump, air conditioner, or furnace size. When the system size is reduced, a cost savings can be realized. For the majority of cases analyzed this year, including this example case, there was no change in size.

Windows, doors, and skylights:

The U-factor for windows and opaque doors is reduced from 0.30 for the ***2018 IECC*** to 0.28 for the ***2024 IECC.*** The U-factor for skylights is reduced from 0.55 for the ***2018 IECC*** to 0.50 for the ***2024 IECC.*** Neither version of the code has a maximum SHGC (solar heat gain coefficient).

Net change: The 2024 IECC requires that windows, doors and skylights utilize glass with a lower U-value.

Cost example: The cost analysis focuses on windows. None of our prototype homes had skylights, but we also reviewed the Home Depot web site and found that the least expensive glass skylight already met the 2024 IECC's requirement of U=0.50, so we believe that this is a cost-neutral change for skylights. Likewise for exterior doors, a search of the Home Depot website found a wide variety of low-cost and best selling opaque and partial-lite doors that meet Energy Star requirements in all climate zones which would provide a U-value less than 0.28.

The energy study considered homes with both 12% and 18% window to wall ratio. The 1852 sf home used in that study has 240 sf of glazing for 12% window to wall ratio and 360 sf of glazing for 18% window to wall ratio. Assuming an average window size of 15 sf, this would be 16 total windows for the 12% case and 24 total windows for the 18% case.

The Energy Star Windows, Doors, and Skylights analysis report from 2021 shows typical upgrade costs per window for ranges of U-factors. Inconveniently for this report, it shows U-factors from 0.28 to 0.31 as having a uniform cost increase from a "baseline" window (defined as U-factor between 0.32 and 0.35) of $6 per window. A further upgrade to a U-factor of 0.27 incurs a $18 premium above "baseline". For the purpose of this report, we have opted to be conservative and assume that there is some cost associated with decreasing the U-factor from 0.30 to 0.28 and that it would be at most $12 per window (the difference between the 0.28-0.31 and 0.27 categories).
Using the online CPI inflation calculator to adjust from Jan. 2021 to Jan. 2025, this cost would increase by 21%.

This would produce a cost increase of $232.32 for the 12% window to wall ratio case: $12 per window multiplied by 16 windows multiplied by 121% for inflation. For the 18% window to wall ratio case the increase would be $348.48: $12 per window multiplied by 24 windows multiplied by 121% for inflation.

Savings: For the 1852 sf case with 18% window to wall ratio, the change to lower U-value glazing reduced energy cost by $40 per year for the heat pump case and $8 per year in the gas furnace case.

Exterior wall insulation:
The ***2018 IECC*** requires either R-20 insulation in wood frame cavity walls or R-5 continuous exterior insulation with R-13 cavity insulation. Costs for this scenario are based on a 2x6 wall with high density fiberglass batt (R-21) cavity insulation, as we anticipate that most builders would prefer to use a 2x6 wall over installing continuous rigid insulation.

The ***2024 IECC*** requires that wood frame walls be insulated with one of four options: (1) R-20 cavity and R-5 continuous exterior, (2) R-13 cavity with R-10 continuous exterior, (3) R-20 continuous exterior, or (4) R-30 cavity. Costs for this scenario are based on a 2x4 wall with R-13 fiberglass cavity insulation and R-10 rigid exterior board insulation. This is based on the assumption that if builders have to choose between installing continuous rigid insulation or building an unusually thick wall, they are likely to drop back to a 2x4 wall as the cheaper option.

Net change: Since the 2024 IECC requires either an unusually think wall or continuous rigid exterior insulation, we anticipate that the lowest cost solution would be to use a 2x4 wall with R-10 continuous exterior rigid insulation. Fiberglass batts are available in high density type (R-15 or R-21) and low density type (R-13 or R-19). The 2x4 with R-13 option would be less expensive both due to the smaller framing members and the ability to install low-density fiberglass batts, which are less expensive.

Cost example: The 1852 sf example home has 2000 sf exterior wall area.
Costs for the 2018 case include framing for a 2x6 wall assembly ($6.506 per sf) and R-21 fiberglass batt insulation installed in a wall ($1.531 per sf). Total cost for framing and insulation is $16,074.
Costs for the 2024 case include framing for a 2x4 wall assembly ($5.776 per sf), R-13 fiberglass batts ($1.041/sf), and 2 inch thick extruded polystyrene R-10 rigid exterior insulation ($3.293 per sf). Total cost for framing and insulation is $20,220. The 2024 IECC results in a cost increase of $4,146 for increased wall insulation.

Savings: The cost analysis shows energy savings of $112 per year for the heat pump case and $25 per year for the gas furnace case when upgrading to the 2024 IECC.

Whole house ventilation system efficiency (CFM/Watt):
Both the ***2018 IECC*** and the ***2024 IECC*** refer to the IRC or IMC, which both require a system using the flow rates specified by ASHRAE Standard 62.2 (assumed 2010 version).
The ***2018 IECC*** required a minimum fan efficiency of 1.4 CFM/Watt.
The ***2024 IECC*** requires a minimum fan efficiency of 2.8 CFM/Watt.
This requirement is most commonly implemented by contractors using a quiet, continuous run bath fan. To meet ASHRAE Standard 62.2, the fan must have a sound rating less than 1 sone.

Net change: The installed fan will need to be more efficient than before, but most fans in the marketplace already meet the new 2024 requirement.
The HVI (Home Ventilating Institute) directory lists bath fans that are tested for sone rating, rated flow, and cfm/watt. That directory currently includes 990 bathroom fans that list both sone rating and CFM/Watt. 577 of these fans are rated at 1 sone or less and could be used for whole-house ventilation. Of these 577 available fans, 575 (99.7%) are rated at 2.8 CFM/Watt or higher and could meet the new requirement. The fans that are rated less than 2.8 CFM/Watt are also rated at 50 cfm or less, so they would not be capable of providing the correct amount of ventilation in any but the smallest homes.

Cost example: We confirmed that on the Home Depot web site the least expensive 80 cfm fan under 1 sone provides more than 2.8 CFM/Watt. Therefore, we consider the upgrade cost to be negligible.
Energy Cost: The cost analysis shows energy savings of $18 per year (both heat pump and furnace cases) when upgrading to the 2024 IECC.

Energy efficient lighting:
The ***2018 IECC*** requires that high-efficacy lighting be used for 90% of installed indoor lamps (light bulbs). Today, this requirement is most frequently met using LED lamps.

The ***2024 IECC*** increases the requirement to 100% high-efficacy indoor lamps. There is also a minor change to the definition of high-efficacy, however standard LED lamps meet the definition of high-efficacy for both versions of the code.

Net change: The 2024 code would require that an additional 10% of the lighting be installed as high-efficacy.

Cost example:
RSMeans does not list cost data for lamps. Costs for A-type lamps were obtained from the Home Depot web site. Costs for various technologies were as follows:

- Dimmable LED lamps: A low cost "top selling" dimmable LED multi-pack (24 lamps) with a light output equivalent to a 60 Watt incandescent was available for $2.42 per lamp.
- Non-dimmable LED lamps: A popular multi-pack of non-dimmable LEDs (16 lamps) from the Home Depot website is available at a cost of $1.00 per lamp.
- CFL lamps: the Home Depot website did not offer any comparable A-type CFL lamps.
- Incandescent and halogen lamps in the 60 Watt range: Offerings on the Home Depot website were limited to specialty lamps that all cost more than $2.42 per lamp, often substantially more.

Based on these findings, we conclude that the market has largely moved to LED lamps and a builder selecting lowest cost fixtures would already be using LED. For the cost impact of this step (upgrading from 90% to 100% LED), we have opted to call this a cost-neutral step. The impact of dimmable LEDs will be included in the next step below.

Savings: The cost analysis shows energy savings of $19 per year (heat pump case) and $30 per year (furnace case) when upgrading to the 2024 IECC.

Dimmer switches and timers

The ***2018 IECC*** does not require dimmer switches or timers on indoor lighting or on intermittent exhaust fans.

The ***2024 IECC*** requires: (1) dimmer switches or automatic shutoff for indoor lighting fixtures in habitable spaces, (2) automatic shutoffs capable of turning lights off within 20 minutes of occupants leaving the space for garages, unfinished basements, laundry rooms, and utility rooms, and (3) timer, occupancy sensor, or humidity control for all intermittent bathroom fans.

Net change: The 2024 IECC will require dimmer switches to be installed for most interior light fixtures. This will also require that slightly more expensive dimmable LED lamps be provided. Automatic shutoffs will be required for lighting in some other spaces and for bathroom fans.

Cost example:
The drawings from which the models were developed show 17 total interior light fixtures on the main level: 4 in bathrooms, 2 in hallways, 1 in a closet, 1 in a laundry room and 9 in other rooms considered "habitable" (bedrooms, living, kitchen, foyer, laundry, etc.). We assume 1 lamp in the bath, hallway, and closet fixtures and 2 lamps in the other fixtures for a total of 27 lamps in the main level of the home. The drawings also show 12 one-lamp fixtures in the basement, bringing the total indoor lighting to 39 lamps.

We believe it would be most common for builders to meet the 2024 IECC requirement for habitable spaces by installing dimmers. The cost of upgrading the 18 lamps in "habitable spaces" to dimmable LED would be $1.42 per lamp (using the costs shown in the previous step). The total cost increase for dimmable lamps would be $25.56.

The is also a cost for the dimmer switches themselves. This home design has 9 total fixtures that require dimmer switches. Costs for dimmer switches can vary widely, and not all dimmers are compatible with all dimmable lamps. We selected a low-cost toggle dimmer switch made by Ariadni and available from Rexel for $26.14 each. A non-dimmable single toggle switch is available from Leviton for $0.98. Based on these costs, the total cost to upgrade 9 switches would be $226.44.

The garage, laundry, and unfinished basement would require an automatic shutoff. For the purpose of this study, we assume that both light fixtures in the garage would likely be on the same switch. The single bulb fixtures shown for the basement would also likely be moved to shared switches – we are assuming 3 switches in the basement. The laundry has a single fixture. The total number of switches requiring automatic shutoff would be 5. We selected a Leviton motion sensor in-wall switch available from Rexel for $37.00. The total cost to upgrade 5 switches would be $185.00.

This plan also has 2 bath fans. Fans intended for intermittent operation would be required to have a timer, occupancy sensor, or humidity control. There are a number of ways to meet this requirement, including some fans that have these functions built in. For this study, we have assumed that one of the bath fans would run continuously for whole-house ventilation and be exempted from this requirement. For the other, we selected a Leviton in-wall timer switch that allows 4 selections of up to 30 minutes from Rexel for $28.72.

The total cost increase for dimmable lamps and the various dimmer and timer switches needed to meet the 2024 IECC would be $465.72.

Savings: Cost savings associated with this code change was not calculated because it depends on the homeowner's usage of the dimming and timer features, which are not standardized features in home energy rating or the Ekotrope software. The calculation shows that once 100% LED lighting is installed indoors, the indoor lighting annual cost is $91 per year and the garage lighting annual cost is $10 per year. If the use of dimmers and timers achieved a 30% savings, the annual savings would be approximately $30.30.

80% of Ducts located inside conditioned space:

The ***2018 IECC*** allows up to 100% of ductwork to be located outside of conditioned space and has requirements for duct leakage that can be met/demonstrated in one of four ways: (1) Postconstruction duct blaster testing demonstrating leakage to outdoors of less than 4 cfm/100 sf of conditioned floor area; (2) Rough-in duct blaster testing demonstrating total duct leakage less than 4 cfm/100 sf of conditioned floor area performed with the air handler installed; (3) Rough-in duct blaster testing demonstrating total duct leakage less than 3 cfm/100 sf of conditioned floor area performed without the air handler installed; or (4) no testing is required if the air handler and all ducts are located inside conditioned space. For the energy modeling portion of this study, it was assumed that the 2018 code case had 50% of its ductwork located inside conditioned space (as is common with homes that have basements in Nebraska) and 2 cfm/100 sf duct leakage to outdoors at final.

The ***2024 IECC*** has similar testing requirements, but one of our selected additional efficiency measures for Section 408 was to bring 80% of ducts inside conditioned space. This measure was selected for the modeling portion of the study, so it is also included in the cost study. The 2024 IECC requires ducts located in conditioned space to be tested, so the testing cost would remain the same between the 2 code cases.

Net change: Many homes in Nebraska have all or part of the HVAC system located inside conditioned space. If this is already the case there would be no cost increase associated with this requirement. This is why we chose ducts inside conditioned space as the optional efficiency upgrade measure for the 2024 IECC. For the 2024 case we assume that 80% of the system and its ductwork are inside conditioned space

Cost example: The Energy Star 3.2 report shows a cost of $2.40 per sf of ductwork to move ductwork inside conditioned space (based on a 2021 database). The prototype house has an estimated 1368 sf of ductwork, so an increase from 50% to 80% located in conditioned space would impact 410 sf of ductwork. The cost to move the ductwork would be $984 (2021 dollars). Using the online CPI inflation calculator to adjust from Jan. 2021 to Jan. 2025, this cost would increase by 21%, to $1190.64

Savings: The cost analysis shows a savings of $344 per year for the heat pump case and $49 per year for the furnace case when upgrading to the 2024 IECC by moving 80% of ducts inside the conditioned envelope.

Duct R-value:
The ***2018 IECC*** specifies minimum duct insulation of R-8 for supply ducts located in attics and R-6 for return ducts located in attics.
The ***2024 IECC*** requires at least R-8 for both supply and return ducts located in attics.

Net change: For the test case modeled for this study, 50% of the ductwork was modeled in the attic for the 2018 IECC and 20% was modeled in the attic for the 2024 IECC.

Cost example: The NREL database shows a cost increase of $0.10 per sf of ductwork to increase the R-value of ductwork from R-6 to R-8. The prototype house has an estimated 370 sf of return ductwork, so increasing the insulation on 20% of this ductwork would impact 74 sf of ductwork. The cost to increase to R-8 return ductwork in the attic would be $7.40.

Savings: The cost analysis shows a savings of $1 (for both the heat pump and furnace cases) per year when upgrading to the 2024 IECC by increasing the R-value of return ducts in attics to R-8.

Tested whole house ventilation fan:
The ***2024 IECC*** introduces a new requirement that requires the whole-house ventilation fan flow rate to be tested. Testing requires either a flow hood (for exhaust fans or other types of systems with accessible inlets/outlets) or a pressure gauge (for certain types of ERV/HRV units) and can typically be performed in less than 10 minutes.

Net change: The change simply requires that a system already required by the code be operating as intended.

Cost example: A HERS rater can test the system if one is involved with the project. If not, most HVAC installation companies own the equipment required and could add this testing to their equipment startup procedure. The Energy Star version 3.1 cost report estimated that this testing would take 12 minutes to perform. RS Means lists the hourly cost of a skilled worker as $41.70 multiplied by a local factor of 0.89 for Omaha Nebraska. This would result in an estimated cost of testing of $7.42.

Cost/savings is neutral: The inclusion of this requirement in the code is based on health and safety and not energy savings. As such, no savings was calculated in the energy study. Fixing a bath fan that was found to not be working properly when tested could also have the benefit of preventing future moisture problems, in addition to improving ventilation.

NEMA OS4 electrical boxes

The ***2018 IECC*** did not have requirements related to NEMA OS4 electrical/communication boxes. A section had been added in the 2021 IECC that required most boxes to be NEMA OS4 rated. The language of this requirement has been relocated to the air sealing section and edited substantially in the ***2024 IECC.*** The new language now requires that only electrical and communication outlet boxes that penetrate the exterior air barrier be tested and rated in accordance with NEMA OS 4. These boxes are designed to be more airtight than typical boxes.

Net change: The 2024 IECC requires an upgraded electrical/communication box when these penetrate the exterior air barrier.

Cost example: The plans for this prototype house show 3 total electrical boxes in locations that would penetrate the exterior air barrier. Two of these are for exterior outlets that would penetrate the exterior house wrap and one is for a garage common wall outlet that would penetrate the garage drywall. All three of these are single gang. Costs from Rexel for Allied Molded brand electrical boxes are $1.85 each for regular and $6.08 each for airtight. In total, the cost to upgrade the 3 boxes in this house to airtight boxes is $12.69.

Savings: Savings were not calculated for this change. While the change is expected to contribute to overall house airtightness, it is difficult to quantify that savings. Since there is no change in overall airtightness required by the two codes, a reduction in airtightness cannot be guaranteed, so it was not calculated.

Changes to fireplaces

The ***2018 IECC*** did not have an equivalent to the new section 403.13 regarding fireplaces in the ***2024 IECC***. The new language now requires on on-demand or intermittent pilot in place of a continuous pilot. Vented fireplace heaters are also required to have an efficiency of at least 50% and be ANSI labeled.

Net change: The 2024 IECC requires an upgraded pilot and sets minimum efficiency requirements. The upgraded pilot could provide energy savings for the gas to operate the pilot when the device is not being used. It could also have indoor air quality benefits, if the design of the fireplace allowed for migration of any combustion components into the conditioned space.

Cost example: Most gas fireplaces already meet this efficiency level, so we consider that part of the upgrade to be cost neutral. To calculate the potential cost increase for an intermittent pilot, we located the 5 lowest cost gas direct vent fireplaces available on fireplaces direct that were sold with the option

of an intermittent pilot vs a standard millivolt ignition. Among these fireplaces, the incremental cost increase for the intermittent pilot ranged from $110 to $316, with an average of $260.
Savings: Savings were not calculated for this change as part of the energy modeling. Online estimates indicate that pilot lights can consume 600-1500 Btu/hr. Using 1,000 Btu/hr for a typical pilot light, and assuming that the pilot light would be operating 20 weeks per year in the case of the continuous pilot, a savings of 33.6 therms/year would be possible using an intermittent pilot. At the rate of $0.427 per therm used for Omaha this would be a $14.35/year annual savings. At the rate of $0.8452/therm used for Black hills energy, the annual savings would be $28.40.

Additional air sealing to meet Section 408:
The ***2018 and 2024 IECC*** both require testing with a blower door, and homes must achieve an airtightness of less than 3 ACH50.
For this report, one of the Section 408 upgrades that we chose to include for the ***2024 IECC*** was further increasing the airtightness to 2.5 ACH50 for the homes with heat pumps.
Net change: For homes with heat pumps, one option for builders to meet Section 408 would be to increase airtightness to 2.5 ACH50.
Cost example: The NREL energy efficiency measures database estimates a cost of $0.31/sf finished floor area to improve airtightness from 3 ACH50 to 2 ACH50. It would likely be easier to achieve the first 0.5 ACH50 of this savings than the second, so we believe a conservative cost estimate would be $0.155/sf, or $287.00 for this home.
Savings: The cost analysis shows a savings of $55 per year when upgrading to the 2024 IECC. This applies to the heat pump case only, since the gas furnace case used another option to meet Section 408.

Furnace efficiency to meet Section 408:
The ***2018 IECC*** does not include Section 408. For this report, one of the Section 408 upgrades that we chose to include for the ***2024 IECC*** was installing a 95% AFUE or higher gas furnace for the homes with furnaces.
Net change: For homes with furnaces, one option for builders to meet Section 408 would be to include a 95% gas furnace. These are very commonly installed already in Nebraska.
Cost example: Since these are commonly installed already in Nebraska and past versions of this report have already been based on 95 AFUE gas furnaces, we did not calculate an added cost to install one.
Savings: We did not calculate an energy savings for this measure, since they are already commonly installed.

Summary:
The tables below summarize expected construction costs and annual energy cost savings for the 1,852 sf ranch-style house with 18% window to wall area.

Code Change	Construction Cost Change	Associated Annual Energy Impact	Simple payback, years	Notes
Glazing U-value	+$348.48	-$40	8.7	Costs and savings shown are for 18% window to wall area.
Exterior wall insulation	+$4146.00	-$112	37	
Increase whole house ventilation CFM/Watt	neutral	-$18	Immediate	Over 99% of capable fans in the marketplace already meet new requirement.
High efficacy lighting	neutral	-$19	Immediate	The lowest cost lamps in the marketplace meet the requirement.
80% of Ducts located in conditioned space	+$1190.64	-$344	3.5	
R-8 return ductwork	+$7.40	-$1	7.4	
Testing of whole house ventilation fan	+$7.42	Not applicable	N/A	*Considered a health and safety upgrade.*
NEMA OS4 electrical boxes	+$12.69	Not calculated	N/A	Contributes to airtightness, but individual impact not calculated.
Dimmer switches, dimmable lamps, and shutoff controls	+$465.72	Estimated -$30	15.5 (est.)	Savings depends on homeowner usage. Estimate is based on 30% annual savings for indoor and garage lighting.
Section 408 – reduce to 2.5 ACH50	+$287	-$55	5.2	
Estimated total	$6465	-$619 (savings)	10.4	

Table. Construction cost, energy savings, and payback for Heat pump case.

Code Change	Construction Cost Change	Associated Annual Energy Impact	Simple payback, years	Notes
Glazing U-value	+$348.48	-$8	43.6	Costs and savings shown are for 18% window to wall area.
Exterior wall insulation	+$4146.00	-$25	166	
Increase whole house ventilation CFM/Watt	neutral	-$18	Immediate	Over 99% of capable fans in the marketplace already meet new requirement.
High efficacy lighting	neutral	-$30	Immediate	The lowest cost lamps in the marketplace meet the requirement.
80% of Ducts located in conditioned space	+$1190.64	-$49	24.3	
R-8 return ductwork	+$7.40	-$1	7.4	
Testing of whole house ventilation fan	+$7.42	Not applicable	N/A	*Considered a health and safety upgrade.*
NEMA OS4 electrical boxes	+$12.69	Not calculated	N/A	Contributes to airtightness, but individual impact not calculated.
Dimmer switches, dimmable lamps, and shutoff controls	+$465.72	Estimated -$30	15.5 (est.)	Savings depends on homeowner usage. Estimate is based on 30% annual savings for indoor and garage lighting.
Section 408 – 95 AFUE gas furnace	neutral	Not calculated		Already very commonly installed.
Gas fireplace intermittent pilot	$260	Estimated $14.35	18.1	May also have health/safety benefits.
Estimated total	$6725	-$175 (savings)	38.4	

Table. Construction cost, energy savings, and payback for Gas furnace case.

The tables above provide cost estimates and savings for the example 1852 sf home constructed in Omaha that has 18% window to wall ratio, and a conditioned basement. Both the heat pump and gas furance/AC cases are shown. The gas fireplace changes are shown only for the home that is heated with a gas furnace, assuming that the heat pump home may be all-electric. The data show a total estimated increase in construction cost for the home of approximately $6465 (heat pump case) to $6725 (furnace case) if the 2024 IECC is adopted, in whole, as the Nebraska Energy Code, providing a simple payback in energy savings of approximately 10 years for the heat pump case and 38 years for the gas furnace case (with no “payback” value assigned to the health and safety items).

A notable difference in this year’s study compared to previous studies is the large difference in payback between the heat pump and gas furnace cases. There are two major reasons for this. The first of these is the way that windows were specified and the sizing of the heat pumps using Manual S. In previous years, an un-realistically high window SHGC was used, which resulted in larger cooling loads and larger heat pump selections. These larger heat pumps relied on less strip backup heat in cold weather. The modeling this year was performed using an SHGC that is more commonly seen in the marketplace, but the smaller system sizes and our use of lower-efficiency single stage equipment caused more energy to be used for both the 2018 and 2024 code cases using heat pumps. Homeowners using heat pumps could reduce this effect by using more efficient multi- or variable speed compressor systems, which are allowed to be upsized to cover more heating using Manual S.

The second difference from previous years was the markedly lower gas cost rated for the Omaha gas utility. For this study we use the average of the previous 12 months gas cost published by the utility. This year, that resulted in a cost of $0.427 per therm for MUD in Omaha. For comparison, the gas cost used this year for Black Hills Energy (Chadron and Norfolk) was $0.8452 per therm. The gas cost used in our 2021 report for MUD in Omaha was $0.793 per therm. It may be that the previous 12 months in Omaha have been an anomaly in gas prices and consumers will see faster payback. Using the Chadron/Norfork rates for this year, the overall payback for this example house would be 19 years.

Since most homes are financed on a 30 year mortgage and energy costs increase each year, it is useful to compare the annual savings with the impact on mortgage rates. With a 7% mortgage interest rate, the additional annual mortgage payment for $6465 to $6725 in construction cost is $516 to $537. With an annual energy cost savings of $619, homeowners with a mortgage using the heat pump system would experience a net annual cost decrease of $103 with the adoption of the 2024 IECC. Homeowners with gas furnaces in Omaha would expect to see an annual savings of $175, which would mean that they would see annual expenses rise by $362 with the adoption of the 2024 IECC. However, if rates for the Omaha gas utility increased to the rate that homeowners in other parts of the state are paying, their annual utility bill savings would be $346 and their net increase in annual expense, including mortgage would only be $190.

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[3]Musser 2006. "Energy Impact Study of the 2003 IECC, 2006 IECC, and 2006 IRC Energy Codes for Nebraska:"

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[8]Musser 2018. "Energy Impact Study of the 2009 IECC and 2018 IECC Energy Codes for Nebraska."

[9]Musser 2021. "Energy Impact Study of the 2009 IECC and 2021 IECC Energy Codes for Nebraska."

[10]ASHRAE Standard 62.2-2010. Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings. Atlanta, GA, American Society of Heating, Refrigerating, and Air Conditioning Engineers.

Appendix A

Heating degree days by code jurisdiction

Jurisdiction	HDD	Modeled City	Jurisdiction	HDD	Modeled City
Albion	7087	Chadron	Louisville	6292	Omaha
Alliance	6823	Norfolk	McCook	5967	None
Alma	6203	Omaha	Mead	6570	Norfolk
Ashland	6379	Omaha	Milford	5779	None
Auburn	5765	None	Minden	6398	Omaha
Beatrice	6151	Omaha	Nebraska City	6023	Omaha
Bellevue	6153	Omaha	Norfolk	6766	Norfolk
Blair	6455	Omaha	North Platte	6766	Norfolk
Bloomfield	7057	Chadron	Ogallala	6672	Norfolk
Cass County	6292	Omaha	Omaha	6153	Omaha
Central City	5834	None	O'Neill	7246	Chadron
Ceresco	6613	Norfolk	Palmyra	6337	Omaha
Chadron	7021	Chadron	Papillion	6153	Omaha
Columbus	6411	Omaha	Plainview	6485	Omaha
Cozad	6303	Omaha	Plattsmouth	6153	Omaha
Crete	5811	None	Ralston	6153	Omaha
Dakota City	6600	Norfolk	Sarpy County	6153	Omaha
David City	6237	Omaha	Saunders County	6613	Norfolk
Douglas County	6153	Omaha	Scottsbluff	6742	Norfolk
Elkhorn	6153	Omaha	Seward	5779	None
Falls City	5795	None	Seward County	5779	None
Fremont	6444	Omaha	Sidney	7092	Chadron
Gering	6742	Norfolk	South Sioux City	6600	Norfolk
Grand Island	6385	Omaha	Superior	5552	None
Gretna	6379	Omaha	Sutton	6347	Omaha
Hall County	6385	Omaha	Tekamah	6564	Norfolk
Hastings	6211	Omaha	Valley	6570	Norfolk
Holdrege	6482	Omaha	Wahoo	6570	Norfolk
Kearney	6652	Norfolk	Washington Cty.	6455	Omaha
Keith County	6672	Norfolk	Waverly	6119	Omaha
LaVista	6153	Omaha	Wayne	7143	Chadron
Lancaster County	6119	Omaha	Wymore	6151	Omaha
Lexington	6303	Omaha	York	6338	Omaha
Lincoln	6119	Omaha	Yutan	6570	Norfolk

Table A1. Modeled city representing Nebraska code jurisdictions.

Appendix B

Glossary of Abbreviations used in this report

ACH50: Air changes per hour at 50 Pascals pressure difference. This is a tested measure of whole-house airtightness that is commonly used to benchmark whole-house airtightness.

AFUE: Annual fuel utilization efficiency. Used to quantify and compare the efficiency of gas furnaces. A higher value indicates better efficiency, with 100% being the theoretical maximum.

ASHRAE: American Society of Heating, Refrigerating, and Air Conditioning Engineers, a global society dedicated to advancing the arts and sciences of HVAC.

cfm: cubic feet per minute, a measure of airflow

EPA: Environmental Protection Agency, an agency of the US federal government.

HVAC: Heating, Ventilating, and Air Conditioning

IECC: International Energy Conservation Code

NOAA: National Oceanic and Atmospheric Administration, an agency of the US federal government.

R-value: measures how well a product prevents heat from moving through the building exterior. A high R-value means that the material has a high resistance to heat flow and is considered a good insulator. R-value is the mathematical inverse of U-factor.

Ekotrope: A whole-house energy modeling tool used to perform this study.

RESNET: Residential Energy Services Network (www.resnet.us) This organization maintains the RESNET standards, a commonly used method of rating the energy performance of homes.

SEER2: Seasonal energy efficiency ratio. Used to quantify and compare the efficiency of air conditioners (and heat pumps in cooling mode). A higher value indicates a more efficient unit. Currently available units range from 14.3 to over 20 SEER2.

sf: square feet

SHGC: Solar heat gain coefficient. A number between 0 and 1 that expresses the portion of incident solar energy that passes through a window, including frame effects. The lower the value, the more solar heat is blocked from entering the home via the window.

U-factor: measures how well a product prevents heat from moving through the building exterior. A low U-factor means that the material has a high resistance to heat flow and is considered a good insulator. U-factor is the mathematical inverse of R-value.