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Energy Impact Study of the 2003 IECC, 2006 IECC, and 2006 IRC Energy Codes for Nebraska

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Executive Summary

The focus of this report is annual residential energy consumption under three energy code conditions. The codes compared are:

- Nebraska's current residential energy code, the 2003 International Energy Conservation Code (IECC), and
- The 2006 International Energy Conservation Code (IECC) and the 2006 International Residential Code (IRC), which have identical requirements when applied to the homes in this study. These codes allow builders two options for exterior wall construction, both of which are investigated.

These codes were compared in the Nebraska cities of Omaha, Chadron, and Norfolk and for houses with 12% and 18% window to wall area ratio.

2003 IECC performs best in most cases

Homes constructed according to the requirements of the 2003 IECC consumed less energy annually for heating and cooling in the Chadron and Norfolk climates. The 2003 IECC also consumed the least energy in Omaha for houses with 18% window to wall ratio.

Based on the results data, we expect that the 2003 IECC will consume less energy for Omaha houses with window to wall ratios in excess of 15%. At 15% or below, the 2006 IECC/IRC will result in less energy consumption.

Key differences between 2003 and 2006 codes

There are several important differences between the 2003 and 2006 IECC codes. Under the 2003 code, Nebraska consisted of four separate climate zones with different insulation requirements for each. The 2006 code combines the entire state into a single climate zone with uniform requirements. The 2006 component insulation requirements are most similar to the 2003 requirements for Omaha, which has one of the state's warmer climates. This is why the 2003 code outperforms in the colder cities of Chadron and Norfolk.
A second key difference between the codes is that the 2003 IECC requires more insulation to be used when houses have a larger percentage of windows. This acts both as an incentive for builders to limit the percentage of windows and to partially offset the increased energy consumption that occurs as the amount of window area increases. The 2006 IECC drops this requirement: there is no limit on the window area that can be installed, and there is no longer a requirement to offset the energy consumed by the larger window area with increased insulation elsewhere in the house. This is why the houses in Omaha with 18% window to wall ratio also used less energy under the 2003 IECC.

A third difference is that the 2006 code allows builders to use less insulation in ceilings and floors if the insulation fills the framing cavity. This potentially allows houses to be constructed with much less insulation than the 2003 code would allow. These lower insulation values were not used in this study, but even without using them, the 2003 IECC used less energy in most cases.

About the Study

The study considers the annual energy consumption of houses constructed according to the 2003 and 2006 IECC energy codes. Energy use was modeled for three cities selected to represent climate zones in the state: Chadron, Norfolk, and Omaha. Energy modeling was performed using Energy Plus, a state of the art modeling tool developed by the U.S. Department of Energy.

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.

The modeling approach and houses used in this analysis were based on those used for a 2003 study of Nebraska energy codes[1]. That 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 2015. With the passage of LB 888 in 2004, Nebraska homeowners began to experience these savings. Since then, gas rates have increased by 15-20% across the state, rather than the approximately 10% increase that was accounted for in the original cost analysis. Therefore we have reason to believe that adoption of the 2003 IECC has helped soften the blow of these price increases for Nebraska homeowners, and that their actual savings may be greater than the original predictions.

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 15 years. She completed 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.

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Introduction

The objective of this study was to compare the energy impact for Nebraska homeowners under the 2003 IECC (International Energy Conservation Code), the 2006 IECC, and the 2006 IRC (International Residential Code). 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 a previous study of the life cycle cost implications of adopting the 2000 IECC as the state energy code[1]. 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 home size, 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 usage patterns were modeled based on national average usage data.

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. A 2002 survey of Nebraska building code officials conducted as part of that study determined that the average Nebraska home built that year was 1,870 square feet (sf) in size. Unfortunately, data on floor area were not available for Omaha, where many of the state's larger homes are likely built. The average new home in Lincoln was approximately 2,200 sf, which supports this assumption. Also, U.S. census data[2] for 2001 report that the median new home in the area defined as "Midwest" was 1,965 sf, and the average new "Midwest" home was 2,209 sf (very large homes skew the average higher).

The census data also include some information on the distribution of sizes. This was used to estimate the 20th and 80th percentile house sizes for the study. The 20th percentile Nebraska home is larger than 20 percent of new homes built in Nebraska. Likewise, the 80th percentile home is larger than 80 percent of new Nebraska homes. By interpolation of the census data, the 20th percentile home in the "Midwest" is approximately 1,450 sf, and the 80th percentile is about 2,900 sf.

The four selected house plans were: a ranch house at the 20th percentile, a ranch house at the mean size determined by the survey of Nebraska code officials, a two story house between the median and average sizes for Midwest homes according to the U.S. Census data, and a two story house at the 80th percentile. Plans and estimating kits were supplied by Design Basics, an Omaha building plan service that supplies plans for 15,000 houses per year. The actual houses modeled, their square footages, and other characteristics are shown in Table 1.

One difference from the previous study is that the four houses were modeled with window to wall area ratios of both 12 and 18%. Previously, the houses were modeled with the actual window area shown on the building plans.

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	2,070
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 survey, 92% of Nebraska houses have basements, and 26% of these are finished basements. All four houses were modeled with conditioned basements. The survey also found that when records on the type of heating and cooling systems installed were available, 67% of new homes have gas-fired forced air furnaces and central air conditioning systems. All four homes were modeled using this type of heating/cooling system.

An air infiltration rate of 0.5 air change per hour was used in modeling the above ground portions of all four houses under all three code conditions. Basements located below grade are modeled with 0.2 air change per hour to reflect their reduced tendency toward air exchange with the outdoors. Air infiltration rates in U.S. houses vary by up to a factor of 10, and have been shown to vary by approximately 15% in identical houses constructed at the same time by the same contractor[3]. The rate of 0.5 air change per hour was selected for the model because it is the median annual infiltration value measured in a study of 312 U.S. houses of "newer, energy efficient construction"[4]. Unless an aggressive air sealing program and independent verification techniques are used, this is the best estimate of the air tightness of a typical home.

Occupant information

Occupant behavior and heat gains associated with people and their activities influence the energy required for heating and cooling. This study assumes a family of four living in each house with one adult and one child who are home during the day, while the other adult and child are away from home during the workday. The heat gain from each adult occupant was modeled as 250 Btu/hr sensible and 200 Btu/hr latent[5]. The two children were modeled as having 75% of this heat gain.

The occupancy schedule is as follows: one adult and one child are modeled as being away from home between 8:00 a.m. and 6:00 p.m. on weekdays and between 10:00 a.m. and 5:00 p.m. on weekends. This occupancy schedule was specified to produce the number of "at home" hours as are recommended by the Environmental Protection Agency's Exposure Factors Handbook[6] for a working American adult. The other two occupants are assumed to have the same weekend activities as the others and to spend two hours each weekday outside the house. Their schedule places them away from home between 2:00 p.m. and 4:00 p.m. on weekdays and between 10:00 a.m. and 5:00 p.m. on weekends.

Thermostat settings

Occupants' use of setback thermostats also influences heating and cooling energy consumption. This model assumes a thermostat setpoint of 70°F in the winter and 76°F in the summer. These conditions are within the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) comfort ranges for people seasonally dressed. No setback thermostat settings were used.

Appliance loads

Sensible internal heat gains include the occupants themselves (discussed above), appliances, and lighting. Heat gains for some appliances, such as refrigerators, are generally independent of occupant activities. The usage of other appliances, such as televisions, depends on occupant activity. Sensible loads for appliances were computed primarily based on national residential statistics published by the Energy Information Administration (EIA)[5]. This report shows that the average American home consumes approximately 34.6 million Btu annually for appliances that contribute to internal heat gain. These gains were broken into two categories: those related to occupants and their activities, and those that are nearly constant. The occupancy-related sources account for 18.2 million Btu, and are (in decreasing order of magnitude): hot water, lighting, clothes dryers, color televisions, cooking, dishwashers, microwave ovens, personal computers, VCRs, clothes washers, stereos, and laser printers. Sources that are independent of occupancy account for 16.4 million Btu and are (in decreasing magnitude): refrigerator, freezer, waterbed heaters, ceiling fans, aquariums, answering machines, battery chargers, cordless phones, fax machines, and residual items. The contribution of each item to energy use is weighted to account for their frequency of occurrence in the nation's housing stock.

Internal heat gains are also related to house size. The EIA reports median energy expenditures based on number of rooms. These were divided by the median national household energy expenditure to obtain a factor that was used to scale the non-occupancy related heat gains. The occupancy related heat gains are more likely to be related to the number of occupants than the size of the house, so they were not scaled.

To coincide with occupant activities, the occupancy-related sources were scheduled to occur from 6:00 a.m. to 8:00 a.m. and from 6:00 p.m. to 10:00 p.m. on weekdays, and from 8:00 a.m. to 10:00 a.m. and 5:00 p.m. to 10:00 p.m. on weekends, for a total of 2,288 hours per year. Heat sources that are independent of occupancy were modeled as constant over the entire year. Table 2 summarizes the internal heat gain values used for the analysis.

House size (sf)	# of rooms	% US average energy cost	Occupant related gains (Btu/hr)	Non-occupant related gains (Btu/hr)
1,453	5	96	7,955	1,790
1,852	6	111	7,955	2,069
2,103	8	143	7,955	2,668
2,932	9	182	7,955	3,413
U.S. Average	N/A	100	7,955	1,872

Table 2. Internal sensible heat gains from equipment.

Latent loads also contribute to a home's cooling energy consumption. For an average family of four, Canada's Institute for Research in Construction[7] recommends the following latent loads: respiration from the occupants themselves, 5,760 Btu/day for occupancy related activities (including showering, bathing, dishwashing, cooking, and cleaning), and 5,760 Btu/day from other sources (including construction moisture, seasonal storage, basements and crawlspaces, rain penetration and unknown sources). Latent loads from the occupants themselves were modeled according to the occupancy schedules. To achieve the daily rates above, latent loads from occupant activities were modeled using the same schedule as for occupancy-related sensible loads at a rate of 960 Btu/hr. The other latent loads were modeled as constant throughout the day at a rate of 240 Btu/hr.

Codes

Three different energy code conditions were modeled. These included the 2003 IECC (International Energy Conservation Code) and two different conditions to represent both the 2006 IECC and the 2006 IRC (International Residential Code). Chapter 11 of the 2006 IRC is nearly identical to Chapter 4 of the 2006 IECC, and the prescriptive requirements for the two codes are identical for the houses in this analysis. Thus for the remainder of this report, these cases will be referred to as the "2006 IECC/2006 IRC".

The 2006 codes contain several major changes. First, the entire state of Nebraska has been included in a single climate zone with uniform requirements throughout the state. Under the 2003 code, Nebraska includes four climate regions with different requirements, with Omaha, Norfolk, and Chadron each falling in a different region. Another change associated with the 2006 codes is that the R-value requirement for wood frame walls for the Nebraska climate may be met using R19 cavity insulation or R13 cavity insulation plus R5 insulated sheathing. Energy consumption was modeled for both of these cases. Another major change associated with the 2006 codes is that their requirements do not change with window to wall area ratio. The 2003 IECC contains more stringent requirements for houses with window to wall ratio exceeding 15%. This means that the component requirements for that code are different for the cases with 12% and 18% window to wall ratio.

Table 3 summarizes the required component values for the code conditions modeled. The requirements shown above in Table 3 are associated with the "simplified prescriptive track" of each code, which is the easiest and most often used means of code compliance. An exception is the requirement for the 2003 18% window to wall ratio cases, for which the simplified prescriptive track cannot be used. A more detailed prescriptive track with similar tabular values taken from Chapter 5 of that code was used instead.

Component	2003 IECC 15% or less window to wall ratio			2003 IECC 18% window to wall ratio			2006 IECC/IRC (case a)	2006 IECC/IRC (case b)
	Omaha	Norfolk	Chadron	Omaha	Norfolk	Chadron		
Glazing U-factor	0.35	0.35	0.35	0.34	0.33	0.33	0.35	0.35
Glazing SHGC	none	none	none	none	none	none	none	none
Opaque door U-factor	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Ceiling R-value	38	49	49	49	49	49	38 (note a)	38 (note a)
Wall R-value	18	21	21	22	22	25	19	13+5 (note b)
Floor R-value	21	21	21	19	25	30	30 (note c)	30 (note c)
Basement wall R-value	10	11	11	10	11	15	10/13 (note d)	10/13 (note d)
Forced air furnace (AFUE)	80%	80%	80%	80%	80%	80%	78% (note e)	78% (note e)
Central air conditioning (SEER) (note f)	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0

Table 3. Component requirements by building code.

Note a: Both codes allow R30 to be substituted if the uncompressed R30 extends over the top plate at the eaves. In the 2006 Code, R30 may also be used for ceiling areas of up to 500 sf with no attic. The 2003 Code does not limit square feet.
Note b: 13+5 refers to R13 cavity insulation plus R5 insulated sheathing.
Note c: Less than R30 may be used if sufficient to fill the framing cavity; with a minimum of R19.
Note d: R10 may be used if insulation is continuous; R13 must be used if insulation is placed in the framing cavity.
Note e: The “prevailing minimum federal efficiency of 78% is required, but 80% is widely installed and was used for the analysis.
Note f: The 2003 IECC required 10.0 SEER, but is no longer available since the minimum federal efficiency increased to 13.0 is 2006. 13.0 SEER is used for the analysis.

There is no Solar Heat Gain Coefficient (SHGC) requirement for glazing in climates with more than 3,500 degree days. For modeling, a default SHGC of 0.66 was used for all cases modeled. This represents double glazed clear fenestration with operable metal frames or fixed nonmetal frames.

The 2006 codes are less stringent than the 2003 IECC in a number of areas. They do not require a lower glazing U-factor for larger window to wall ratios. The 2006 required ceiling R-value and wall R-value are lower than that required for all but the Omaha 12% case under the 2003 codes. Also, the 2006 codes allow R values that are significantly lower than the 2003 code 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, thus casting the 2006 codes in their most favorable light.

The R-value for framed floors over unconditioned spaces required by the 2006 code is larger than that required by the 2003 codes. However, the houses in this study had only small areas of this type of floor, which was limited primarily to framed floors over garages. The 2006 codes also require more basement wall insulation than most of the 2003 cases. Modeling was performed with basement insulation in cavity walls, so R13 was used for the 2006 code.

Mechanical equipment efficiencies were modeled as 80% AFUE for forced air furnaces and 13.0 SEER for air conditioning for all of the cases. The 2006 codes do allow a 78% AFUE furnace to be installed, but 80% AFUE is widely used and comparable in cost. Likewise, the 2003 code did allow a 10.0 SEER air conditioning unit to be used, but these are no longer available due to an increase in the federal minimum efficiency requirement.

Climates

Three cities were chosen to represent the climate variation in Nebraska. These cities represent different heating degree day categories used in the 2003 IECC to specify required thermal performance of envelope components. 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 4 summarizes the degree day categories, 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 degree days).

Degree day range (2003 IECC)	City	Annual heating degree days
6,000-6,499	Omaha	6,153
6,500-6,999	Norfolk	6,766
7,000-8,499	Chadron	7,021

Table 4. Selected Nebraska cities and climates.

Component Selection

Since energy consumption, rather than installed cost, is being considered, it was not necessary to perform a detailed selection for every construction component. However, 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 more detail.

Windows

Window U-factor is influenced by the framing material, window glass, number of panes, gas used to fill the space between panes, and application of low-e coatings. This allows for a large number of possibilities to meet a specific U-factor, and it was therefore assumed that a builder could find a window that met the minimum requirements of each code condition. Thus, each code condition is modeled with a window having exactly the prescribed U-factor and a default solar heat gain coefficient (SHGC) of 0.66. For reference, a U-factor of 0.35 can typically be achieved using a double glazed vinyl window with ½ inch argon fill and low-e coating.

Exterior wall insulation

Wall insulation is typically available in specific increments of R-value, and was selected as such for this analysis. Table 5 summarizes the required insulation R-value, the framing required, and the insulation products used. In two cases, a slightly higher than required nominal R-value was obtained using readily available products. The R21 wall was constructed with an actual R-value of 22, and the R25 wall has an actual R-value of 25.5.

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 0.25 was used; this means that the wood construction makes up 25% of the wall surface area. Rigid insulation is often used in place of exterior sheathing, with wood sheathing used at the corners for shear bracing. Because the 2006 codes allow this structural sheathing to cover up to 25% of the wall area without requiring an additional layer of insulation, a framing factor of 0.25 was also used for rigid insulation.

R-value (°Fft^{2}hr/Btu)	Wall construction	Wall insulation type
18	2 x 4	3-½” R15 fiberglass batts plus ½” isocyanurate rigid insulation
13+5	2 x 4	3-½” R13 fiberglass batts plus ¾” isocyanurate rigid insulation
19	2 x 6	5-½” R19 fiberglass batts
21	2 x 6	5-½” R19 fiberglass batts plus ½” isocyanurate rigid insulation
22	2 x 6	5-½” R19 fiberglass batts plus ½” isocyanurate rigid insulation
25	2 x 6	5-½” R21 fiberglass batts plus ¾” isocyanurate rigid insulation

Table 5. Wall insulation combinations used to meet code requirements.

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, the insulation was placed in a framed cavity on the interior of the basement wall. Table 6 shows the basement wall insulation combinations used to meet the code requirements. All of the combinations result in the minimum required R-value except for the R10 requirement, which was met with R11 fiberglass batts.

R-value (ºFft^{2}hr/Btu)	Basement wall insulation type
10	3 ½" R11 fiberglass batts
11	3 ½" R11 fiberglass batts
13	3 ½" R13 fiberglass batts
15	3 ½" R15 fiberglass batts

Table 6. Basement wall insulation combinations used to meet code requirements.

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. One floor plan also contains a small amount of cathedral ceiling (about 5% of the overall roof area) directly beneath a sloped roof supported by 2 by 10 inch joists. For these sections, batt insulation was used between the joists for the 2006 codes, making use of the provision to allow R30 to be used on areas of less than 500 sf with no attic. The 2003 code requires more insulation, so foamed in place polyurethane is substituted. Table 7 summarizes the roof/ceiling insulation combinations that were used to meet the codes.

R-value (ºFft^{2}hr/Btu)	Insulation location	Insulation type
30	Cathedral ceiling	9" R30 fiberglass batts
38	Cathedral ceiling	9 ¼" foamed in place urethane (approx. R6 per inch)
49	Cathedral ceiling	9 ¼" foamed in place urethane (approx. R6 per inch)
38	Attic floor	15.2" blown-in fiberglass insulation (R2.5 per inch)
49	Attic floor	19.6" blown-in fiberglass insulation (R2.5 per inch)

Table 7. Roof and ceiling insulation combinations used to meet code requirements.

Floor insulation

Insulation requirements for framed floors over unconditioned space were met using the insulation combinations shown in Table 8. In each case, the exact minimum insulation requirement was used. Note that when 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.

R-value (ºFft^{2}hr/Btu)	Insulation type
19	5-½" R19 fiberglass batts
21	5-½" R21 fiberglass batts
25	9" R25 fiberglass batts
30	9" R30 fiberglass batts

Table 8. Floor insulation combinations used to meet code requirements.

Exterior doors

The U-factor requirement for opaque doors was 0.35 Btu/hrft^{2}ºF for all of the codes. The opaque portions of all doors were modeled with this U-factor.

Results

Annual energy simulations were performed for the four houses under the three code conditions to determine their annual energy consumption. Comparison of the results shows that the 2003 IECC requires less energy for heating and cooling than the 2006 cases for all houses and climates except for Omaha with 12% window to wall ratio. In that case, the 2006 codes consume less energy due to their higher wall and basement R-value requirements.

Energy use

Annual energy consumption for heating and cooling was determined using an annual hourly calculation performed using *Energy Plus*. Because the orientation of the house impacts the energy consumption, each of the house/city/code conditions was simulated with the house facing due North, South, East, and West, and these four results averaged to obtain one energy consumption value for each condition.

Tables 9 and 10 show the annual HVAC-related electricity and gas consumption of each house under each code condition. Gas consumption tracks the heating requirement for each house. Because the HVAC fan requires electricity when the system operates, the electricity consumption is related to both heating and cooling, but is dominated by cooling loads.

Several trends are observable within this data set. As would be expected, more energy is generally required to heat and cool larger houses than smaller ones. There are two exceptions to this trend. The 2,103 sf house consumes approximately the same cooling energy as the 2,932 sf house. This occurs because of window overhangs and greater heat dissipation to the larger basement of the larger house. Also, the 2,103 sf 2 story house has a smaller heating load than the 1,852 sf ranch house. This is primarily due to the larger heat loss from the larger basement on the ranch house.

Another readily observable trend is that houses with 18% window to wall ratio generally consume much more cooling energy than the same house with a 12% window to wall ratio. In general, larger window area also increases heating energy consumption, though this effect is partially offset by solar heat gain through the windows. Under the 2003 code some houses with larger window areas actually require less heating energy due to the more stringent envelope requirements of that code for larger window to wall areas. This effect is not seen for the 2006 codes since its envelope requirements are the same for all window to wall area ratios.

In all cases except for those houses in Omaha with a 12% window to wall area ratio, the 2006 code cases consume more energy than the 2003 code. This is because the 2006 codes have lower ceiling and wall R-values than the 2003 code does for these cities and window conditions. The only difference between the 2006(a) and 2006(b) code is the exterior wall insulation. The 2006(a) code condition has R19 cavity insulation, while the 2006(b) code condition has R13 cavity insulation plus R5 rigid insulation. Since this analysis uses the same framing factor for both cavity and rigid insulation, the 2006(b) case always has a slightly lower installed R-value than the 2006(a) case and consumes slightly more energy for both heating and cooling.

The 2006 codes do provide slightly lower annual energy consumption in Omaha for the houses with 12% window to wall ratio. This is because the 2006 code requires slightly higher R-values for exterior walls, basement walls, and floors over unconditioned spaces for homes with 12% window to wall ratios. Based on these results and the insulation requirements for the various codes, we expect that homes built under the 2006 codes in Omaha will consume less energy for houses with window to wall ratios of 15% or less than homes built under the 2003 code. Houses with greater than 15% window to wall ratio in Omaha will consume less energy under the 2003 code.

Code	City	Window/ wall ratio	1,453 sf ranch	1,852 sf ranch	2,103 sf 2 story	2,932 sf 2 story
2003 IECC	Omaha	12%	3462	3805	5214	5179
2006 IECC/IRC (a)	Omaha	12%	3389	3690	5127	5092
2006 IECC/IRC (b)	Omaha	12%	3461	3800	5210	5173
2003 IECC	Omaha	18%	3780	4208	5719	5716
2006 IECC/IRC (a)	Omaha	18%	3825	4270	5768	5849
2006 IECC/IRC (b)	Omaha	18%	3888	4368	5864	5912
2003 IECC	Norfolk	12%	2979	3230	4624	4447
2006 IECC/IRC (a)	Norfolk	12%	3029	3297	4679	4513
2006 IECC/IRC (b)	Norfolk	12%	3107	3419	4806	4695
2003 IECC	Norfolk	18%	3411	3794	5301	5198
2006 IECC/IRC (a)	Norfolk	18%	3457	3856	5347	5257
2006 IECC/IRC (b)	Norfolk	18%	3526	3966	5456	5415
2003 IECC	Chadron	12%	2202	2309	3627	3279
2006 IECC/IRC (a)	Chadron	12%	2244	2363	3655	3330
2006 IECC/IRC (b)	Chadron	12%	2313	2475	3687	3356
2003 IECC	Chadron	18%	2596	2787	4271	3955
2006 IECC/IRC (a)	Chadron	18%	2639	2857	4308	4021
2006 IECC/IRC (b)	Chadron	18%	2703	2959	4324	4028

Table 9. Annual HVAC-related electricity consumption (kWh).

Code	City	Window/ wall ratio	1,453 sf ranch	1,852 sf ranch	2,103 sf 2 story	2,932 sf 2 story
2003 IECC	Omaha	12%	366	566	493	893
2006 IECC/IRC (a)	Omaha	12%	340	530	453	833
2006 IECC/IRC (b)	Omaha	12%	363	562	489	886
2003 IECC	Omaha	18%	341	528	461	823
2006 IECC/IRC (a)	Omaha	18%	348	538	466	844
2006 IECC/IRC (b)	Omaha	18%	370	568	508	892
2003 IECC	Norfolk	12%	410	630	525	967
2006 IECC/IRC (a)	Norfolk	12%	419	642	531	979
2006 IECC/IRC (b)	Norfolk	12%	445	678	581	1048
2003 IECC	Norfolk	18%	418	638	548	975
2006 IECC/IRC (a)	Norfolk	18%	427	649	555	989
2006 IECC/IRC (b)	Norfolk	18%	452	683	602	1055
2003 IECC	Chadron	12%	407	626	524	968
2006 IECC/IRC (a)	Chadron	12%	415	638	533	983
2006 IECC/IRC (b)	Chadron	12%	443	676	574	1043
2003 IECC	Chadron	18%	405	619	534	956
2006 IECC/IRC (a)	Chadron	18%	424	645	559	995
2006 IECC/IRC (b)	Chadron	18%	451	682	596	1050

Table 10. Annual HVAC-related gas consumption (therm).

Figures 1 and 2 show graphically the annual electricity and gas consumption of each code case for the 1852 square foot house (the Nebraska average) with 12% window to wall ratio. As discussed above, Omaha is the only city in which the 2006 codes out-perform the 2003 IECC. If the option to use R13 cavity insulation plus R5 rigid insulation is selected (the 2006b case), the difference between the 2006(b) and 2003 codes for the Omaha 12% case is so small that it can be considered negligible.

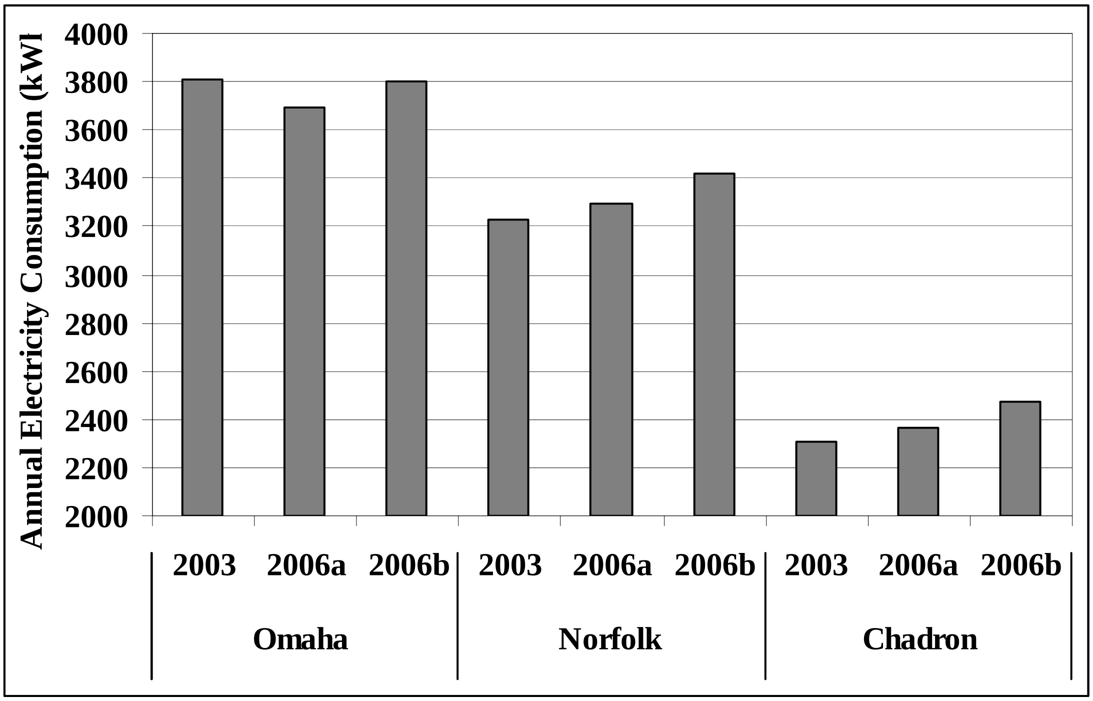

Figure 1. Annual Electricity Consumption for 12% Window to Wall Area Ratio.

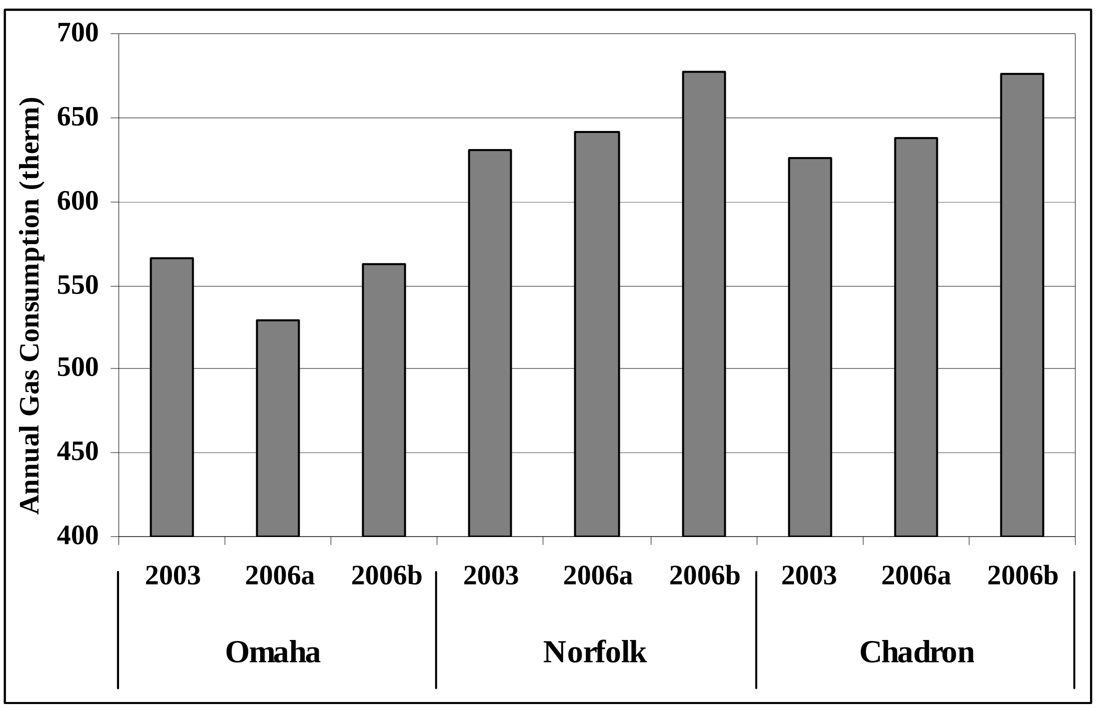

Figure 2. Annual Gas Consumption for 12% Window to Wall Area Ratio.

Figures 3 and 4 show graphically the annual electricity and gas consumption of each code case for the 1852 square foot house with 18% window to wall ratio. In all cases, the 2003 IECC outperforms the 2006 codes.

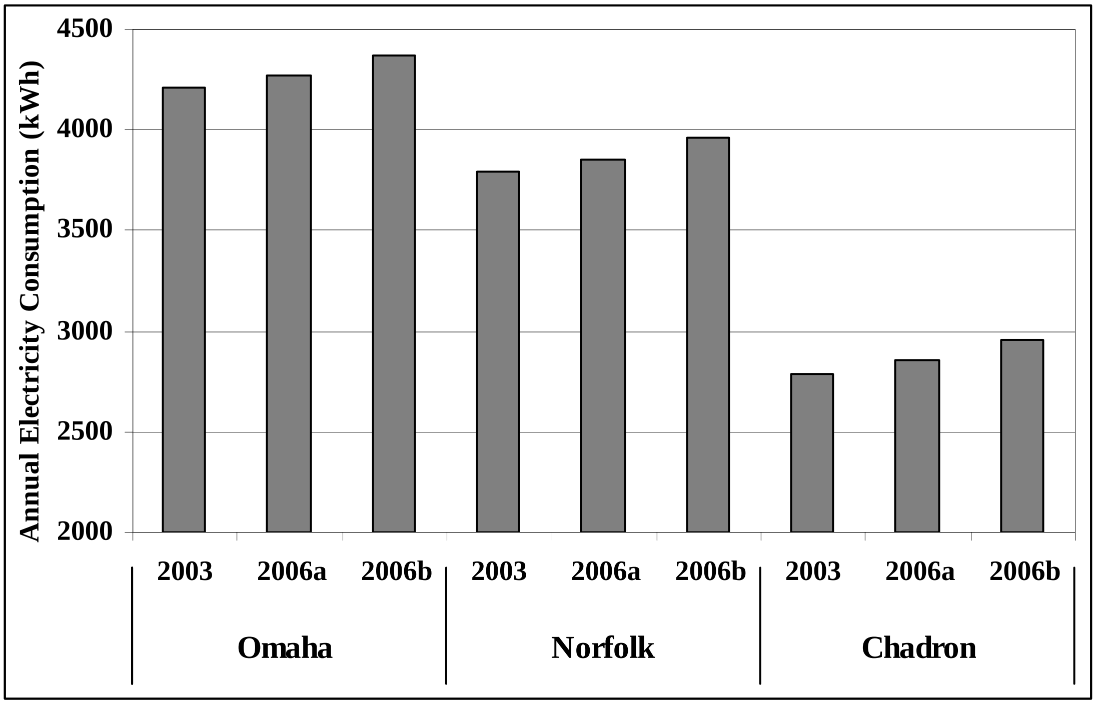

Figure 3. Annual Electricity Consumption for 18% Window to Wall Area Ratio.

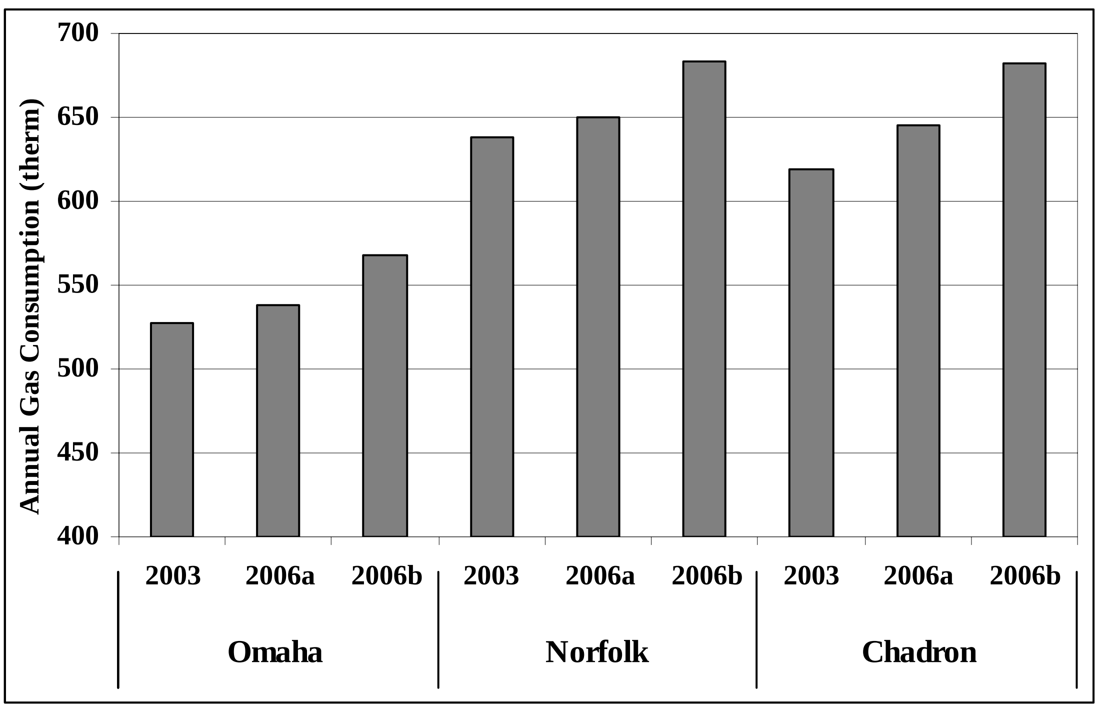

Figure 4. Annual Gas Consumption for 18% Window to Wall Area Ratio.

Conclusion and recommendations

The findings of this study indicate that the 2003 International Energy Conservation Code currently required by Nebraska state law results in homes that consume less energy in most circumstances.

Although the 2006 International Energy Conservation Code and the nearly identical 2006 International Residential Code do result in slightly lower energy consumption for the Omaha jurisdiction and climate for houses with 12% window to wall ratio, it results in greater energy consumption for 18% window to wall ratio in Omaha. Since neither of these codes place any limitation on window to wall ratio, there is a concern that adoption of either of these codes would result in an increase in the number of homes built with larger window areas, and that these homes would be less energy efficient than those built under the 2003 IECC. Observation of the data in this study indicate that the “break point” at which the 2006 codes become less efficient than the 2003 IECC in Omaha is 15% window to wall ratio.

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Appendix

Number of permits and heating degree days by code jurisdiction

Jurisdiction	Permits	HDD	Modeled City	Jurisdiction	Permits	HDD	Modeled City
Albion	7	7087	Chadron	Louisville	3	6292	Omaha
Alliance	5	6823	Norfolk	McCook	7	5967	None
Alma	3	6203	Omaha	Mead	1	6570	Norfolk
Ashland	32	6379	Omaha	Milford	6	5779	None
Auburn	6	5765	None	Minden	3	6398	Omaha
Beatrice	35	6151	Omaha	Nebraska City	9	6023	Omaha
Bellevue	300	6153	Omaha	Norfolk	65	6766	Norfolk
Blair	56	6455	Omaha	North Platte	53	6766	Norfolk
Bloomfield	1	7057	Chadron	Ogallala	12	6672	Norfolk
Cass County	121	6292	Omaha	Omaha	2136	6153	Omaha
Central City	1	5834	None	O'Neill	4	7246	Chadron
Ceresco	1	6613	Norfolk	Palmyra	3	6337	Omaha
Chadron	9	7021	Chadron	Papillion	142	6153	Omaha
Columbus	60	6411	Omaha	Plainview	2	6485	Omaha
Cozad	7	6303	Omaha	Plattsmouth	20	6153	Omaha
Crete	10	5811	None	Ralston	2	6153	Omaha
Dakota City	7	6600	Norfolk	Sarpy County	281	6153	Omaha
David City	7	6237	Omaha	Saunders County	47	6613	Norfolk
Douglas County	42	6153	Omaha	Scottsbluff	19	6742	Norfolk
Elkhorn	64	6153	Omaha	Seward	24	5779	None
Falls City	1	5795	None	Seward County	22	5779	None
Fremont	40	6444	Omaha	Sidney	35	7092	Chadron
Gering	32	6742	Norfolk	South Sioux City	23	6600	Norfolk
Grand Island	101	6385	Omaha	Superior	1	5552	None
Gretna	166	6379	Omaha	Sutton	2	6347	Omaha
Hall County	24	6385	Omaha	Tekamah	4	6564	Norfolk
Hastings	59	6211	Omaha	Valley	4	6570	Norfolk
Holdrege	8	6482	Omaha	Wahoo	13	6570	Norfolk
Kearney	116	6652	Norfolk	Washington Cty.	79	6455	Omaha
Keith County	50	6672	Norfolk	Waverly	15	6119	Omaha
LaVista	115	6153	Omaha	Wayne	11	7143	Chadron
Lancaster County	34	6119	Omaha	Wymore	5	6151	Omaha
Lexington	7	6303	Omaha	York	19	6338	Omaha
Lincoln	1140	6119	Omaha	Yutan	4	6570	Norfolk

Table A1. 2001 Residential Permits by Nebraska code jurisdiction.