PNNL-14090

Assessment of Impacts from Updating Iowa's Residential Energy Code to Comply with the 2000 International Energy Conservation Code

R. G. Lucas

November 2002

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

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Richland, Washington 99352

Summary

The state of Iowa currently requires that new buildings comply with the Council of American Building Officials' (CABO) *1992 Model Energy Code* (MEC) (CABO 1992). CABO has been transformed into the International Code Council (ICC) and the MEC has been renamed the *International Energy Conservation Code* (IECC). The most recent edition of the code is the 2000 IECC (ICC 1999). Iowa's Department of Natural Resources requested that the U.S. Department of Energy (DOE) compare the 1992 MEC with the 2000 IECC to estimate impacts from updating Iowa's residential energy code to comply with the new code. Under DOE's direction, Pacific Northwest National Laboratory (PNNL) completed an assessment of the impacts from this potential code upgrade, including impacts on construction and energy consumption costs.

Despite the change in the code's appearance, most of the requirements for residential buildings in the 1992 MEC and 2000 IECC have similar energy efficiency requirements. Some specific requirements in the 2000 IECC are more stringent than those in the 1992 MEC. The most significant differences between the 1992 MEC and the 2000 IECC for residential buildings in Iowa are as follows:

- The thermal wall requirements for multifamily buildings have become substantially more stringent in the 2000 IECC–the allowed heat loss rates are about one-third lower than those allowed in the 1992 MEC. Despite this improvement, the requirements in the IECC for many multifamily buildings will be less-stringent than those for the typical single-family house.

- Specific provisions have been added to the 2000 IECC for recessed lighting fixtures to limit heat loss/gain by air infiltration.

The 1992 MEC and 2000 IECC have numerous other differences, but most of these differences are minor and will likely have little or no impact on energy efficiency or construction costs for most residential buildings. The 2000 IECC is much larger than 1992 MEC and has been restructured considerably from the MEC. Some changes affect only certain regions of the United States that do not include Iowa. Notable other code differences affecting Iowa include the following:

- Windows now have to be rated by the National Fenestration Ratings Council or be assigned an unfavorable U-factor, which establishes credible ratings for window performance.

- Foam insulation on the exterior of foundation walls must have a protective covering when above grade.

The impacts on construction costs and energy savings from updated residential energy efficiency standards vary depending on several factors, including the type of dwelling and specific design elements. Some residential buildings would need several improvements to comply with an upgraded energy code; others may comply unchanged. For example, the thermal envelope requirements for multifamily buildings have become considerably more stringent, but the requirements for single-family houses are unchanged. Construction cost increases from adopting the 2000 IECC are expected to vary from zero to about $500 for most houses or

multifamily dwelling units. Many buildings should have no construction cost increases. The main cost impacts are expected to be from:

- envelope improvements to multifamily buildings (up to about $500 per unit)
- a protective covering for exposed exterior foundation insulation (up to about $200 if applicable)
- improved sealing for recessed light fixtures (up to $50 or more, depending on the number of fixtures)
- improved duct sealing, about $200.

All of the changes to the 2000 IECC are clearly cost-effective with a simple payback of about 7 years or faster, except the requirement for a protective covering for exposed exterior foundation insulation. This requirement cannot be shown to be cost-effective from an energy efficiency standpoint, although it is a sensible preventive measure to improve long-term durability.

Contents

1.0 Introduction

The state of Iowa currently requires that new buildings comply with the Council of American Building Officials' (CABO) *1992 Model Energy Code* (MEC) (CABO 1992). CABO has been transformed into the International Code Council (ICC) and the MEC has been renamed the *International Energy Conservation Code* (IECC). The most recent edition of the code is the 2000 IECC (ICC 1999). Iowa's Department of Natural Resources requested that the U.S. Department of Energy (DOE) compare the 1992 MEC with the 2000 IECC to estimate impacts from updating Iowa's residential energy code to comply with the new code. Under DOE's direction, Pacific Northwest National Laboratory (PNNL) completed an assessment of the impacts from this potential code upgrade, including impacts on construction and energy consumption costs.

This report contains the findings of this assessment. Section 2.0 discusses the impacts from major differences in the 1992 MEC and 2000 IECC and Section 3.0 discusses impacts from minor differences, including impacts on construction and energy costs. Section 4.0 contains a list of publications cited in this report.

2.0 Impacts from Major Differences in 1992 MEC and 2000 IECC

This section discusses the most significant differences between the 1992 MEC (CABO 1992) and the 2000 IECC (ICC 1999) for residential buildings in Iowa: 1) the thermal wall requirements for multifamily buildings, and 2) provisions for recessed lighting fixtures to limit heat loss/gain by air infiltration. The IECC defines multifamily buildings as three stories or less above grade that contain three or more dwelling units (usually apartments or condominiums) as residential buildings and high-rise multifamily buildings as commercial buildings.

2.1 Thermal Wall Requirements for Multifamily Buildings

The component heat loss and heat gain (U_o) requirements for multifamily residences changed dramatically between 1992 and 2000 (specifically in 1993).

The 2000 IECC has considerably more-stringent requirements for exterior walls (including windows and doors) in multifamily buildings than the 1992 MEC. These requirements are shown in Figure 1 (page 66) of the 1992 MEC and Figure 502.2(1) (page 71) of the 2000 IECC. These requirements are reproduced in Figure 2.1 for the range of heating degree-days that encompass Iowa climates.

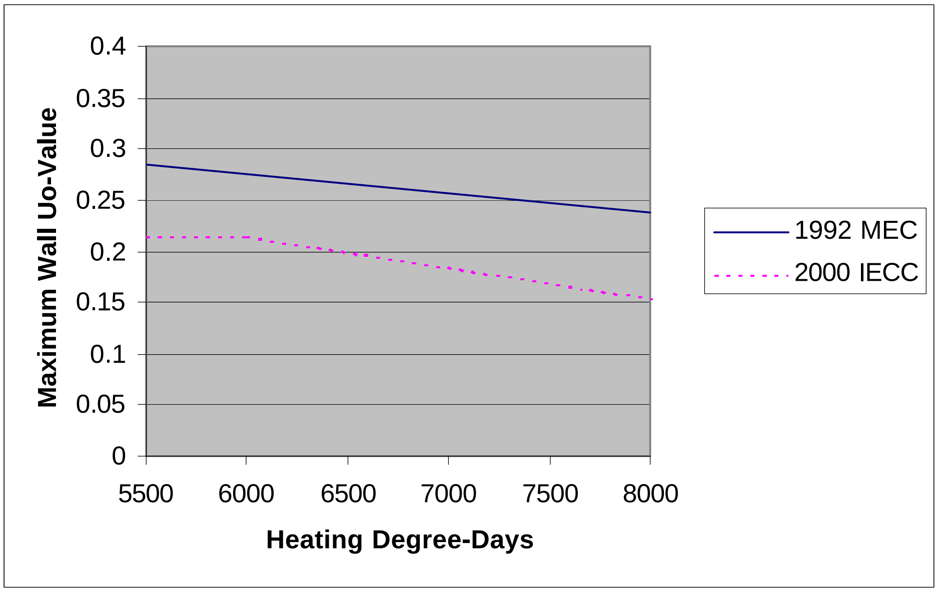

Figure 2.1. Thermal Wall Requirements for Multifamily Residences in Iowa

The MEC*check*™ software illustrates examples of the differences in window U-factor and wall insulation requirements between the 1992 MEC and 2000 IECC for multifamily buildings (see Table 2.1). The packages in this table are for a building with a window-to-wall area percentage of 20%. The MEC and IECC establish requirements for exterior walls (including windows and doors) that vary as a function of the window area as a percentage of the gross wall area. Window U-factor and wall insulation requirements become more stringent as the window area percentage increases and less stringent as the window area percentage decreases. We assumed the building was two stories with six, 1100-ft^2 dwelling units. The building was 27.5-ft wide and 120-ft long, with a total wall area of 4720 ft^2 and a window area of 944 ft^2 for the whole building, or 157 ft^2 per dwelling unit.

The requirements for multifamily residences in the 1992 MEC are very lenient and would probably not result in any more energy efficiency than would occur in a free market in Iowa with no energy code. The 1992 MEC includes packages that allow multifamily residences with no basement or slab insulation to comply. Alternately, if the basement or slab is insulated, very lenient energy efficiency measures can be used elsewhere in the building, such as R-19 ceiling insulation and double-pane aluminum windows (perhaps even single-pane). The envelope requirements for multifamily buildings in the 2000 IECC are more in line with the IECC's requirements for single-family buildings, although multifamily buildings will often still have less-stringent requirements than are required for houses. About 30% of new housing construction in Iowa is multifamily.

Table 2.1. Comparison of 1992 MEC and 2000 IECC Requirements in MEC*check*™ Software for Multifamily Residences

Code	Package	Window U-Factor	Ceiling	Wall	Floor	Basement Wall	Slab Perimeter
1992 MEC	Option A	0.80	R-19	R-13	R-19	R-13	R-2, 2 ft
	Option B	0.50	R-30	R-13	R-11	None	None
2000 IECC	Option A	0.50	R-30	R-13	R-11	R-13	R-2, 2 ft

The IECC allows flexibility in meeting energy efficiency requirements using trade-offs so that buildings can comply with the code if the annual energy use is sufficiently low, even if individual code requirements are not met. Builders can add several possible improvements to the building design to comply with the more-stringent thermal requirements for walls in multifamily buildings. The requirements depend on the building design (e.g., the window-to-wall area percentage) and the climate where the building will be located. Issues related to insulating basement walls (or basement ceilings if the basements are unheated) were debated when Iowa adopted the 1992 MEC[a] and are not addressed here.

If insulation is required in basements in single-family homes, insulation should also be required in multifamily buildings. Beyond basement insulation, modest levels of energy efficiency will likely result in compliance with the IECC for most multifamily buildings. Wood or vinyl windows usually have U-factors as low, or lower (lower is better) than the U-0.50 shown in Table 2.1 for 2000 IECC compliance. Because these types of windows are already widely used in Iowa, this improvement is reasonable. Cost data from California show that vinyl windows cost about the same as aluminum windows (Xenergy, Inc. 2001).

We used the Energy-10 simulation tool to estimate the energy savings from basement insulation in a multifamily building in Des Moines (Sustainable Buildings Industry Council 1999). We assumed a 6,600-ft^2 building with a heated basement. We also assumed natural gas heating at $0.60/therm and electricity at 9 cents/kWh. The 2 in. of exterior foam insulation on the basement wall saved $77 per year per dwelling unit. Assuming the highest cost from the Greiner (1996) report of $1400 for 2 in. of foam

(a) T. H. Greiner of Iowa State University. Letter to Iowa Building Code Commissioner dated December 11, 1996. Iowa State University, Ames, Iowa.

insulation and scaling this to a 295-ft perimeter of the multifamily building gives a cost of about $3,100, or an average of $510 per dwelling unit. The simple payback will be 7 years for the exterior basement insulation. This assumption is one possible insulation configuration for basements. Heated basements can also be finished and have batt insulation in the framing cavities. Unheated basements can have insulation under the floor above the basement and insulated ducts.

2.2 Recessed Lighting

The 2000 IECC specifically requires that recessed (canned) lighting fixtures be carefully sealed. The 1992 MEC does not have this requirement, although it does require that all "openings" in the building envelope be "caulked, gasketed, weatherstripped, or otherwise sealed." Although this requirement may seem like a minor construction detail, unsealed recessed lighting fixtures are a surprisingly large source of air leakage, resulting in increased heating and cooling costs.

The incremental cost of recessed lighting fixtures is about $5 per fixture (*Energy Design Update* 1994). We estimate the typical new house may have about 10 of these types of fixtures exposed on the top to an attic or in a cathedral ceiling, although this number can vary dramatically. Our sources indicate airtight recessed lighting is very cost-effective for the homeowner. Research in both the laboratory and in actual houses indicates that air leaks out of a single typical recessed lighting fixture at about 5 cfm during winter conditions in colder climates, increasing energy costs by $5 or more a year (*Energy Design Update* 1994). We estimate that properly sealing each recessed lighting fixture that is exposed to an attic or other unconditioned space can save $5 a year in Iowa. Therefore, investing in improved recessed lighting fixture sealing can pay off in energy savings in about one year.

Note that these impacts can only be expected to occur if the specific requirements for recessed lighting are enforced. Enforcing the requirement to use airtight recessed lighting should be straightforward for light fixtures that are labeled as airtight. Airtight fixtures or housings for recessed lighting may already be in use in Iowa, although we suspect these types of fixtures are typically not used.

3.0 Impacts from Minor Differences 1992 MEC and 2000 IECC

The 1992 MEC (CABO 1992) and 2000 IECC (ICC 1999) have numerous minor differences that will likely have little or no impact on energy efficiency or construction costs for most residential buildings in Iowa. This section discusses these minor differences and their impacts on construction costs and energy consumption impacts.

3.1 Assumptions for Determining Wall U_o-Values for Wood-Frame Walls

The envelope component heat loss and heat gain (U_o for overall U-value) requirements for single-family residences did not change between 1992 and 2000 for Iowa locations. A change in referenced standards in the 2000 IECC has indirectly made the 2000 IECC slightly more stringent in terms of wall insulation requirements. The 1992 MEC references an older version of the ASHRAE Handbook of Fundamentals (the 1985 edition) and the 2000 IECC references a newer version of the handbook (the 1997 edition) (ASHRAE 1985, 1997). Previously, the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) recommended assuming the framing occupied 15% of the gross wall area, now ASHRAE recommends 25%. Because framing (usually wood) loses more heat than insulation between the framing, the 2000 IECC coupled with its referenced standards will give a less-favorable U_o-value calculation than the1992 MEC for any given wall.

It is possible that many users will determine wall U_o-values independently using the version of the handbook referenced in the code, in which case the envelope insulation and glazing requirements for single-family buildings have not changed at all in Iowa.

- **Construction Cost Impacts**: The potential increase in construction cost is very slight because most houses that comply with the 1992 MEC will also comply with the 2000 IECC. If a house design barely complies with the 1992 MEC, it may fail to comply with the 2000 IECC. In this case, numerous options exist to make the slight improvements needed to comply with the 2000 IECC. For example, a 2% increase in furnace efficiency (AFUE) or a 0.04 improvement in the U-factor of the windows should be sufficient. We would expect construction cost increases related to this issue to be minor–generally zero but no more than about $100 in most cases.

- **Energy Consumption Impacts**: If there is a slight improvement in the energy efficiency of the envelope as a result of the change in wall heat loss/gain calculations, a modest amount of energy can be saved.

3.2 Protective Covering for Exposed Foundation Insulation

The 2000 IECC requires that above-grade exposed foundation insulation have a protective covering to protect it from damage. The covering should be "rigid, opaque, and weather resistant," and it must cover the exposed area and extend 6 in. below grade. Many houses do not have any exterior foundation insulation but instead have interior insulation in the floor above basements or crawlspaces or on basement walls. This code requirement would not affect these houses.

- **Construction Cost Impacts**: In 1996, DFI Pultruded Composites, Inc., in Erlanger, Kentucky, was reported to sell a product called Insul-Guard for $1.07 and $2.14 per lineal ft for 12-in.-wide and 24-in.-wide panels, respectively, with quantity discounts available

(*Energy Design Update* 1996). For typical houses, total costs may range from $100 to $200 for the 12-in.-wide panels. Other products and methods of protecting exposed foundation insulation are available, including vinyl or stucco-like coatings. Builders are expected to quickly find the lowest cost methods of protecting exposed foundation insulation.

- **Energy Consumption Impacts**: The protective covering potentially may lengthen the life of the insulation by preventing damage.

3.3 Insulation for Vented Crawlspaces

Insulating the walls of crawlspaces with ventilation openings is no longer an option in the IECC. If the crawlspace is ventilated, insulation on the ceiling of the crawlspace and on conditioned basement walls adjacent to the crawl space is required. The levels (R-values) of insulation have not changed in the 2000 IECC; only the options for placement of the insulation have changed. The reason for this code change is that the vents may be left open in the winter, allowing cold air to flow into the crawlspace, greatly reducing the benefit of the wall insulation.

- **Construction Cost Impacts**: This requirement may increase the construction cost if the builder prefers ventilated crawlspaces with wall insulation and the updated code forces the builder to insulate the ceiling instead. Insulating the crawlspace walls and not venting the crawlspace is a recommended construction method.

- **Energy Consumption Impacts**: This requirement may potentially save some energy. When crawlspaces are vented, the 1992 MEC allows the wall of the crawlspace to be insulated instead of the ceiling. The value of crawlspace wall insulation is greatly diminished if the occupants fail to close the vents during the winter.

3.4 Heat Traps on Water Heaters

The 2000 IECC requires heat traps on water heaters. A heat trap is a device or an arrangement of piping that keeps the buoyant hot water from circulating through the piping distribution system because of natural convection. Most new water heaters come equipped with heat traps as a standard feature.

- **Construction Cost Impacts**: The incremental cost is only $2 to $5 (DOE 2000).

- **Energy Consumption Impacts**: The energy savings for electric water heaters is 0.20 MBtu/yr, or $4.00/yr. The energy savings for natural gas water heaters is 0.48 MBtu/yr, or $2.81/yr (DOE 2000).

3.5 Skylight Shaft Insulation

In the 2000 IECC, skylight shafts 12 in. or greater in depth passing through unconditioned spaces, such as attics, are required to have R-19 insulation. The 1992 MEC includes all building elements separating conditioned spaces from the exterior as part of the “building envelope.” Skylight shafts fit this description; thus, the 1992 MEC technically requires that they be insulated or, if not, that the design make up for the lack of insulation elsewhere. However, because this construction element is specifically called out in the 2000 IECC with a clear requirement, skylight shafts are somewhat more likely to be insulated.

- **Construction Cost Impacts**: No substantial cost impact is expected. Most new houses will not have this construction element.

- **Energy Consumption Impacts**: This requirement may result in a modest energy savings in houses with skylight shafts.

3.6 Duct Insulation

The duct insulation R-value requirements in the 1992 MEC were changed and restructured for the 2000 IECC. In both codes, minimum duct R-values depend on the temperature difference between the air inside the ducts and the air outside the ducts at design (worst-case) conditions. In the 2000 IECC, most ducts in unconditioned spaces, such as attics, basements, and crawlspaces, need to be insulated to R-5. In the 1992 MEC, the R-value requirements vary continuously with the temperature difference inside and outside the ducts.

- **Construction Cost Impacts**: None. The duct insulation requirements have not increased and, in fact, may have decreased in many cases. (Note: duct insulation was increased to R-8 for supply ducts in the 2001 Supplement to the IECC [ICC 2001].)

- **Energy Consumption Impacts**: No significant impacts are expected. Determining the duct insulation R-value requirements in the 1992 MEC was complicated; thus compliance with these requirements was probably low, particularly when high R-values were required.

3.7 Duct Sealing

Duct-sealing provisions in the 2000 IECC apply to all supply and return ducts. The code states that duct tape is no longer permitted as a sealant, although the code text is contradictory because it allows all UL-rated tapes, which can include duct tapes. The 1992 MEC did not require sealing for ducts located inside the conditioned space or return air plenums.

- **Construction Cost Impacts**: Costs for improved duct sealing may vary from zero to several hundred dollars depending on how thoroughly the code is enforced. Significant improvements in duct sealing may raise construction costs by several hundred dollars but is probably a very good investment. One study reports a $214 cost for improved duct sealing (Hammon and Modera 1996).
- **Energy Consumption Impacts**: Substantial energy savings of 10% or more from heating and cooling could result from increased emphasis on duct sealing. Improved duct sealing can pay back in a few years. Improved energy efficiency in ducts is a major benefit that can result from HERS (Home Energy Rating System) ratings.

Comment: Studies have shown that even in new homes in states that have energy efficiency codes, ducts are often poorly sealed and are quite inefficient at delivering heated and cooled air to the registers. The state of Iowa should consider targeting improved duct sealing by training HVAC installers and increasing code enforcement, including spot-testing with a “duct blaster” and similar tests.

3.8 Window and Door Air Leakage

The maximum air leakage rates for windows and sliding doors have been decreased to 0.3 ft^3 per min. per ft^2 of area.

- **Construction Cost Impacts**: No significant impact. The leakage rates maintain consistency with the latest industry standard (AAMA/NWWDA 1997), so most windows probably meet this requirement.

- **Energy Consumption Impacts**: No significant impact is expected.

3.9 National Fenestration Rating Council Ratings

Fenestration products must now be rated by the National Fenestration Rating Council (NFRC) standards for thermal and solar properties, although default values for products not evaluated to the NFRC standards are provided.

- **Cost Impact**: None. Window manufacturers are not required to have their products rated; default values can be used instead. Over 80,000 window products have now been rated.

- **Energy Consumption Impacts**: The requirement for rated windows may save some energy by improving accuracy and creating a level playing field. Without the NFRC ratings, windows could readily be purported to have a better U-factor than the true U-factor, lowering energy efficiency.

3.10 Steel Stud-Framed Walls

Criteria have been added to specifically correct for increased heat loss from steel stud framing in exterior wall thermal calculations.

- **Construction Cost Impacts**: None expected. Exterior steel stud-framed walls are rare and the 2000 IECC criteria are not intended to change the stringency of the code.

- **Energy Consumption Impacts**: None expected.

3.11 Prescriptive Path for Additions and Window/Skylight Replacement

The 2000 IECC contains a new simple prescriptive path (Section 502.2.5) of envelope requirements for replacement windows and for additions less than 500 ft^2 with a total glazing area no greater than 40% of the addition's gross wall and roof area. Skylight replacements must have a U-factor of 0.50 or less. This new option for additions and window replacements is not intended to increase or decrease the stringency of the code, but rather provide clear and unambiguous requirements. Determining how to comply with envelope-related code requirements for additions is less clear without this simple approach. Note that the requirements in this path are stringent for Iowa climates: R-49 ceiling insulation, R-21 wall insulation, and U-0.35 windows.

- **Construction Cost Impacts**: No significant impact is expected. The new prescriptive criteria for additions are an extra alternative compliance path; the other compliance paths are unchanged from the 1992 MEC (unless noted elsewhere in this report). Because this change only adds an extra optional path, it arguably cannot be interpreted as increasing the stringency of the code.

- **Energy Consumption Impacts**: No significant impact is expected, although this requirement may improve energy efficiency via better code compliance and enforcement for small additions and window replacements.

3.12 Optional Prescriptive Compliance Approaches – Section 502.2.4 and Chapter 6

Chapter 6 in the 1992 MEC entitled, "Building Design by Acceptable Practice," has been integrated into Chapter 5 of the 2000 IECC (Section 5.2.2.3). A new Chapter 6 has been added to the 2000 IECC that contains a 4-page optional and standalone prescriptive compliance approach for residential buildings. This approach can be used only if the window area is less than or equal to 15% of the wall area for a single-family building, and less than or equal to 25% of the wall area for a multifamily building. A more extensive prescriptive approach that allows almost any window area percentage has been added to the IECC in Section 502.2.4.

- **Construction Cost Impacts**: None. This change in Chapter 6 is basically just structural. Because this new version of Chapter 6 simply repackages other requirements in the IECC, it is not intended to create any new or different requirements–only a simpler and more concise prescriptive approach. The prescriptive packages in Section 502.2.4 and Chapter 6 are based on implementing the criteria of IECC Table 502.2 and its associated figures for typical construction. These packages are not intended to change the energy efficiency of the code, although they were developed with conservative assumptions to ensure energy efficiency is not decreased.

- **Energy Consumption Impacts**: None expected.

3.13 Expanded Set of Rules for System Analysis Approach - Chapter 4

Chapter 4 in both the 1992 MEC and 2000 IECC permits compliance via a systems analysis approach, also known as a "performance" path. This approach allows any building design to comply with the code if the builder can show that the proposed building has sufficiently low annual energy use. Software specifically designed to simulate building energy use would normally be used to show compliance. The basic performance approach in the code has not changed since 1992; however, the expanded "ground rules" (directions on how to perform this analysis) have changed. The 2000 IECC contains fairly detailed directions on what assumptions should be made in the analysis whereas the 1992 MEC does not provide these detailed directions. For example, the 2000 IECC specifies that in the input to the simulation software, the thermostat should be set at 68°F for heating with a nighttime setback to 63°F, and set to 78°F for cooling. The 1992 MEC does not provide any guidance on thermostat operation. The 2000 IECC also sets stringent baseline requirements for the "Standard Design" wall and fenestration (windows).

- **Construction Cost Impacts**: Small; usually none. These expanded rules were intended to provide clarification on how to perform the analysis to estimate annual energy use, not to make the code more or less stringent. However, the 2000 IECC has new, lower wall and fenestration U-values for the "Standard Design" that may effectively make the code more stringent for many residential buildings if the performance path is used. Because the Chapter 4 approach is only one of several options in terms of compliance paths, this change does not necessarily mean higher construction costs. In fact, the Chapter 4 compliance approach may be infrequently used because it is the most complicated approach (although user-friendly software can make this approach much more attractive).

- **Energy Consumption Impacts**: This change may improve energy efficiency somewhat when the performance path (the Chapter 4 methodology) is used.

3.14 Solar Heat Gain Coefficient Requirement of 0.4 in Warm Climates

Glazed fenestration products (windows, skylights, doors with windows) are limited to a maximum 0.4 solar heat gain coefficient (SHGC) in climates with less than 3500 heating degree-days. From a national perspective, this requirement is perhaps the most notable residential requirement in the 2000 IECC that is not in the 1992 MEC. However, this requirement does not affect Iowa because Iowa does not have locations with heating degree-days this low.

- **Construction Cost Impacts**: None.

- **Energy Consumption Impacts**: None.

4.0 References

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