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

R. G. Lucas

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Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RL01830

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Summary

The current North Dakota state energy code is the Council of American Building Officials' (CABO) *1993 Model Energy Code* (MEC) (CABO 1993). Local jurisdictions can choose to adopt this code. CABO has been transformed into the International Code Council (ICC) and the MEC has been renamed the *International Energy Conservation Code* (IECC) (ICC 1999). North Dakota's Department of Community Services requested that the U.S. Department of Energy (DOE) compare the 1993 MEC with the 2000 IECC to estimate impacts from updating North Dakota's residential energy code to be consistent with the 2000 IECC model code[a]. 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 1993 MEC and 2000 IECC have similar energy efficiency requirements. The 1993 MEC and 2000 IECC have numerous 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 (in terms of number of pages) than the 1993 MEC and has been restructured considerably from the MEC. Some changes affect only certain regions of the United States that do not include North Dakota. Notable code differences contained in the 2000 IECC but not the 1993 MEC include the following:

- In the 2000 IECC, windows have to be rated by the National Fenestration Ratings Council (NFRC) to receive full credit. NFRC establishes credible ratings for window performance.

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

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

- Changes to the wall and window requirements in the Chapter 4 "Systems Analysis" compliance approach that increase stringency if this approach is chosen by the builder.

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; many others may comply unchanged. Construction cost increases from adopting the 2000 IECC are expected to vary from $0 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:

- a protective covering for exposed exterior foundation insulation (up to about $200 if applicable)

[a] The 2000 and 2003 versions of the IECC are very similar. A summary of the differences is found in the appendix.

- improved sealing for recessed light fixtures (up to $50 or more, depending on the number of fixtures)

- improved duct sealing, from $0 to about $200.

All of the changes to the 2000 IECC are clearly cost-effective with a simple payback of about 7 years or less, except the requirement for a protective covering for exposed exterior foundation insulation. This requirement was not cost-effective from an energy efficiency standpoint, but is valuable for improving long-term durability.

Contents

1.0 Introduction

The current North Dakota state energy code is the Council of American Building Officials' (CABO) *1993 Model Energy Code* (MEC) (CABO 1993). Local jurisdictions can choose to adopt this code. CABO has been transformed into the International Code Council (ICC) and the MEC has been renamed the *International Energy Conservation Code* (IECC) (ICC 1999). North Dakota's Department of Community Services requested that the U.S. Department of Energy (DOE) compare the 1993 MEC with the 2000 IECC to estimate impacts from updating North Dakota'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 discusses impacts from the differences in the 1993 MEC and the 2000 IECC, including impacts on construction and energy costs. Section 3.0 contains a list of publications cited in this report. A summary of the changes from the 2000 IECC to the latest published IECC, the 2003 IECC, is presented in the appendix.

2.0 Impacts from Differences 1993 MEC and 2000 IECC

The 1993 MEC and 2000 IECC have numerous minor differences that will likely have little or no impact on energy efficiency or construction costs for most residential buildings in North Dakota. This section discusses these minor differences and their impacts on construction costs and energy consumption impacts.

2.1 Recessed Lighting

The 2000 IECC specifically requires that recessed (canned) lighting fixtures be carefully sealed. The 1993 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.

- **Construction Cost Impacts**: The incremental cost of recessed lighting fixtures is estimated to be about $5 per fixture based on cost data from 1994 (*Energy Design Update* 1994). We estimate that 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 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 per year (*Energy Design Update* 1994).

- **Energy Consumption Impacts**: 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 North Dakota. Therefore, investing in improved recessed lighting fixture sealing can pay off in energy savings in about 1 year.

2.2 Assumptions for Determining Wall U_o-Factor for Wood-Frame Walls

The envelope component heat loss and heat gain (U_o for overall U-factor) requirements for single-family residences did not change between 1993 and 2000 for North Dakota locations. A change in referenced standards in the 2000 IECC has indirectly made the 2000 IECC arguably slightly more stringent in terms of wall insulation requirements. The 1993 MEC references an older version of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) Handbook of Fundamentals (the 1985 edition) and the 2000 IECC references a newer version of the handbook (the 2001 edition) (ASHRAE 1985, 2001). Previously, 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-factor calculation than the1993 MEC for any given wall. This difference in framing assumptions is accounted for in the REScheck code compliance software issued by DOE.

- **Construction Cost Impacts**: The potential increase in construction cost from the revision of the reference standard (the ASHRAE Handbook) is very slight because most houses that comply with the 1993 MEC will also comply with the 2000 IECC. If a house design barely complies with the 1993 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. It is expected that construction cost increases related to this issue would 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.

2.3 Expanded Set of Rules for Systems Analysis Approach - Chapter 4

Chapter 4 in both the 1993 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 1993; 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 1993 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 1993 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). The performance path has requirements that are more stringent than those in the prescriptive requirements in Chapter 5 of the IECC for most designs.

- **Construction Cost Impacts**: None if the performance approach is not used. 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-factors for the "Standard Design" that will 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 will improve energy efficiency in most homes when the performance path (the Chapter 4 methodology) is used.

2.4 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 by the 2000 IECC.

- **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.

2.5 Protective Covering for Exposed Foundation Insulation

The 2000 IECC requires that above-grade exposed foundation insulation have a 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**: There are a variety of options for protecting exterior foundation insulation (including fiberglass, vinyl, or stucco products) with costs varying from $0.17/ft^2 to $1.48/ft^2 (*Energy Design Update 2003*). For typical houses, total installed costs can be under $200. Builders are expected to quickly find the lowest cost methods of protecting exposed foundation insulation.

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

2.6 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 floor above the crawlspace and on conditioned basement walls adjacent to the crawlspace 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 floor above the crawlspace instead.

- **Energy Consumption Impacts**: This requirement may save some energy. When crawlspaces are vented, the 1993 MEC allows the wall of the crawlspace to be insulated instead of the floor above the crawlspace. The value of crawlspace wall insulation is greatly diminished if the occupants fail to close the vents during the winter.

2.7 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 $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).

2.8 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 1993 MEC includes all building elements separating conditioned spaces from the exterior as part of the "building envelope." Skylight shafts fit this description; thus, the 1993 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 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.

2.9 Duct Sealing

Duct-sealing provisions in the 2000 IECC apply to all supply and return ducts. Tapes and mastics used to seal ductwork have to meet UL standards. The 1993 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 ducts are sealed. Significant improvements in duct sealing may raise construction costs by several hundred dollars but is probably a 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. Payback for improved duct sealing can be just a few years.

2.10 Window and Door Air Leakage

The maximum air leakage rates for windows and sliding doors have been decreased from 0.34 (for wood) and 0.37 (for aluminum and PVC) 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.

2.11 Steel Stud-Framed Buildings

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

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

- **Energy Consumption Impacts**: None expected, given the minimal application of exterior steel stud-framed residences.

2.12 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 North Dakota 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 is an *alternative* compliance path; the other compliance paths are unchanged from the 1993 MEC. Because this change only adds an extra optional compliance 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.

2.13 Optional Prescriptive Compliance Approaches – Section 502.2.4 and Chapter 6

Chapter 6 in the 1993 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. The prescriptive requirements in Chapter 6 are shown in Figure 2.1. A more extensive prescriptive approach, which 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 only 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.

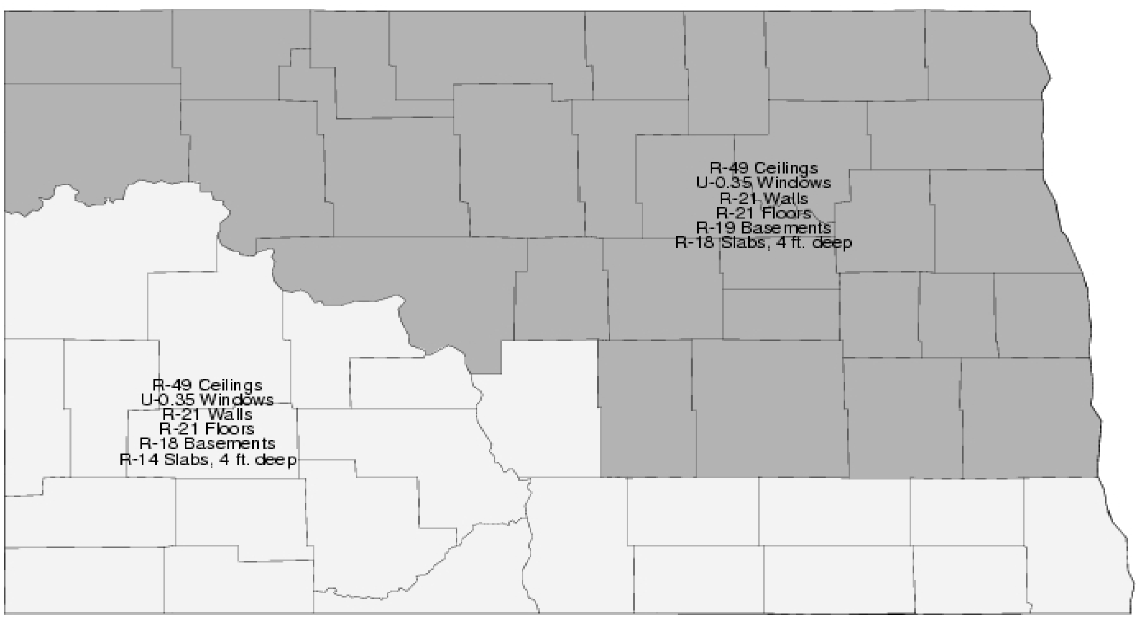

Figure 2.1. 2000 IECC Requirements for 15% Window-to-Wall Area Single-Family Houses

2.14 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 1993 MEC. However, this requirement does not affect North Dakota because North Dakota does not have locations with heating degree-days this low (North Dakota heating degree-days are from 8400 to 10800).

- **Construction Cost Impacts**: None.

- **Energy Consumption Impacts**: None.

3.0 References

American Architectural Manufacturers Association and National Wood Window and Door Association (AAMA/NWWDA). 1997. *ANSI/AAMA/NWWDA 101/I.S.2.97*, "Voluntary Specifications for Aluminum, Vinyl (PVC) and Wood Windows and Glass Doors." Schaumberg, Illinois.

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APPENDIX

Comparison of the 2003 IECC to the 2000 IECC

Appendix

Comparison of the 2003 IECC to the 2000 IECC

The International Code Council (ICC) has recently issued the 2003 editions of their family of codes, including the International Energy Conservation Code (IECC). The requirements for residential buildings in the 2003 IECC are largely the same as those in the 2000 IECC. Increased duct insulation and lenient envelope requirements for sunroom additions are the main changes. Other changes to the code are minor and have little or no effect on code stringency.

Duct insulation requirements have changed from the R-5 or R-3.3 required in the 2000 IECC. In the 2003 code, duct insulation levels are set based on heating degree-days (hdd), duct location, and duct type (supply or return). Supply and return ducts in attics are generally required to have R-8 and R-4 insulation, respectively. Ducts in other unconditioned spaces such as basements, crawlspaces, and garages generally have requirements of R-4 to R-8 for supply ducts and R-2 for return ducts.

A special set of requirements has been added to the code for sunroom additions. Sunroom additions are permitted to have ceiling, wall insulation, and window U-factor requirements typically less stringent than the requirements for all other types of residential construction. To qualify, the sunroom addition must

- Be capable of being controlled as a separate zone.
- Not be used as kitchens or sleeping rooms.
- Meet the envelope requirements of the IECC for any new walls, doors, or windows between the sunspace and the house.
- Have the glazing area be in excess of 40% of the gross area of the exterior walls and roof of the sunroom.

Requirements tables were added for steel-frame ceilings and floors that complement already existing IECC steel wall requirements. Providing simple methods of complying with steel-framed building codes, these tables are intended to provide requirements equivalent in energy efficiency to those already in the code for wood-framed ceilings and floors.

The performance path in Chapter 4 of the IECC contains a variety of modest improvements that make the chapter simpler and briefer. For example, unnecessary text about crediting renewable energy has been deleted. Other changes enhance the accuracy or completeness of the requirements or make them more sensible (e.g., internal heat gain assumptions improved).

There are two changes that can increase the stringency of the code in certain cases. First, any house proposed to use electric resistance heating must be compared against the "standard design" having an electric air source heat pump. This change makes the performance approach more stringent for electric resistance heating designs. Second, a provision has been added that the worst possible orientation, in terms of energy use, be assumed for a group of residences in a development with identical designs.

An additional change allows climate zones identified in Chapter 3 to now be used with the prescriptive envelope requirements in Chapter 6 and Section 502.2.4 of the code. These prescriptive tables can be used with either the hdd or the Chapter 3 climate zone maps, whereas in the 2000 IECC, only hdd could be used. For most locations, the Chapter 3 climate zones and hdd lead to the same envelope requirements. Using the climate map zones in the maps instead of the hdd will allow about 10% of cities nationwide to have less stringent prescriptive requirements. However, about 20% of cities nationwide will have more stringent requirements when the climate zones are used with the prescriptive requirements. This change brings consistency between the IECC, the International Residential Code, and the REScheck™ compliance materials developed by the U.S. Department of Energy. REScheck has always used the map-based climate zones for its prescriptive requirements.

Many of the changes to the IECC are intended to improve code wording. Definitions have been added, and some terminology has changed. Residential building definitions were revised to better align with the IRC and International Mechanical Code definitions. The A-1 and A-2 residential designations are no longer used-they have been replaced with the R-2 and R-4 classifications from the International Building Code (IBC) and the term "detached one- and two-family dwellings."