PNNL-13835

Assessment of Impacts from Adopting the 2000 International Energy Conservation Code for Residential Buildings in Illinois

R. G. Lucas

February 2002

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

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Pacific Northwest National Laboratory
Richland, Washington 99352

Summary

The state of Illinois currently does not have a statewide building energy efficiency code. However, a number of jurisdictions in Illinois have adopted the International Code Councils' (ICC) 2000 *International Energy Conservation Code* (IECC) (ICC 1999). A number of other jurisdictions are interested in doing so. Rather than do piecemeal studies to inform the decision process in individual jurisdictions, the U.S. Department of Energy (DOE) decided to do a statewide analysis based on the 2000 IECC with the 2001 Supplement (ICC 2001) as a mandatory requirement for new buildings.

DOE has requested Pacific Northwest National Laboratory (PNNL) to estimate the energy savings, economic impacts, and pollution reduction from adopting the 2000 IECC[1]. This report addresses the impacts for low-rise residential buildings. A separate PNNL report addresses commercial buildings.

Our analysis indicates that homes built to meet the IECC requirements will save Illinois homeowners money by reducing long-term energy costs by far more than the construction-related cost increases. Homeowners with a typical mortgage should realize a net positive cash flow within a few years or less. Construction cost increases and energy savings will vary depending on many factors, including location, fuel prices, house size and characteristics, construction costs, and the energy efficiency measures used to comply with the IECC. Our analysis also indicates that a significant improvement in pollution reduction can be achieved.

[1] Including the 2001 Supplement.

Contents

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1.0 Introduction

The state of Illinois currently does not have a statewide building energy efficiency code. However, a number of jurisdictions in Illinois have adopted the International Code Councils' (ICC) 2000 *International Energy Conservation Code* (IECC) (ICC 1999). A number of other jurisdictions are interested in doing so. Rather than do piecemeal studies to inform the decision process in individual jurisdictions, the U.S. Department of Energy (DOE) decided to do a statewide analysis based on the 2000 IECC with the 2001 Supplement (2001 IECC)(ICC 2001) as a mandatory requirement for new buildings.

DOE has requested Pacific Northwest National Laboratory (PNNL) to estimate the energy savings, economic impacts, and pollution reduction from adopting the 2000 IECC[2]. This report addresses the impacts for low-rise residential buildings. A separate PNNL report addresses commercial buildings.

Section 2.0 of this report provides an overview of the 2000 IECC. Assumptions used in our analysis are discussed in Section 3.0. Section 4.0 discusses the impacts from adopting the 2000 IECC for residential buildings in Illinois. Section 5.0 provides conclusions from our analysis and Section 6.0 contains a list of publications referenced in this report.

[2] Including the 2001 Supplement.

2.0 Overview of the 2000 IECC

The IECC is a nationally recognized model code that contains requirements for the energy efficient design and construction of all building types, in all U.S. locations. Chapters 4, 5, and 6 of the IECC contain specific requirements for residential buildings and Chapters 1 and 2 contain general information applicable to both residential and commercial buildings. The residential building category is defined as single-family houses, duplexes, and multifamily residential buildings three stories or less above-grade in height. Multifamily buildings include apartments, condominiums, and dormitories, but do not include hotels and motels.

For residential buildings, the IECC primarily addresses energy use from space heating, space cooling, and water heating. Energy savings resulting from the IECC will be from reduced space heating and air conditioning; savings from water heating are expected to be negligible.

Perhaps the most significant requirements for residential buildings are the insulation levels for the building envelope, including walls, ceilings, floors, and the perimeter of slab-on-grade foundations. Energy-efficient windows with low U-factors are generally needed to achieve compliance with the IECC. These envelope requirements become more stringent as the climate becomes colder, so more insulation may be required in northern Illinois than in southern Illinois.

The IECC has important requirements for sealing and insulating ductwork that passes through unconditioned spaces, such as unheated basements and attics. All openings, such as penetrations and cracks in the building envelope, must be sealed as well. The IECC has requirements for space heating, air conditioning, and water heating equipment efficiency, but because these requirements are not more stringent than Federal equipment manufacturing standards, these requirements will have no real impact for Illinois.

The IECC has different building envelope requirements for single-family buildings (including duplexes) and multifamily buildings. The requirements for single-family buildings are generally more stringent than those for multifamily buildings. Lighting for residential buildings is addressed only for multifamily buildings, and then only for the “non-dwelling” portions of the buildings—laundry rooms, recreation rooms, etc.

The IECC allows trade-offs where some energy efficiency measures can fall below code requirements for a specific measure if other measures exceed code requirements. For example, it may be possible to reduce wall insulation if more efficient windows or a high-efficiency furnace are used. The IECC allows any trade-off as long as the estimated total annual energy use does not increase. Several relatively easy-to-use software products are available to assist in designing a building that complies with the IECC, including DOE’s free MEC*check*™ software (DOE 1995).

3.0 Assumptions Used in Our Analysis

Many of the IECC requirements are for features that are already standard in new houses. For example, thermostats must be installed. To determine what IECC requirements go beyond current typical construction practice in Illinois, we had to first identify Illinois "current practice." To determine current practice, we used survey data collected by the National Association of Home Builders (NAHB) Research Center and anecdotal information from individuals familiar with new home construction in Illinois.

Our analysis only examined what we believe to be current practice in Illinois. Some new houses, apartments, and condominiums will be built with higher energy efficiency levels than current practice, while others will be lower. Construction cost impacts and energy savings from the IECC will go up or down accordingly. For example, builders who use above-average energy efficiency practices may already be complying with the IECC.

For our analysis, we assumed a two-story, single-family house with a conditioned floor area of 2,240 ft^2. The prototype had an unheated basement that was not included in the floor area. We also assumed the house had 8-ft-high ceilings, a ceiling area (bordering the unconditioned attic) of 1,120 ft^2, a gross exterior above-grade wall area of 2,176 ft^2, a basement ceiling area of 1,418 ft^2, and a basement wall area of 1,088 ft^2. We assumed a total door area of 56 ft^2 (approximately three doors) and a window area of 314 ft^2 (14% of the floor area). Prototype houses in the cities of Aurora and Springfield were examined as representative upstate and mid-state locations. For this analysis, the only difference between these two locations is the colder climate in Aurora and the more stringent IECC requirements associated with the colder climate.

Table 3.1 shows assumed insulation levels and window types used in our analysis for current practice and for IECC compliance for the prototype house. We used the MEC*check*™ software to select the measures complying with the IECC (DOE 1995). The software notifies the user if a set of insulation levels, window measures, and heating and cooling efficiencies complies with the IECC. The IECC has other requirements not included in Table 3.1, but those shown in the table are the primary requirements that should affect energy usage and construction costs. The Appendix contains the output reports from MEC*check*™. Note the MEC*check*™ software generally allows code compliance with slightly less stringent requirements than the prescriptive packages in Section 502.2.4 and Chapter 6 of the IECC.

Window area (more specifically, window area as a percentage of wall area) is one design element that has an important impact on compliance. The IECC does not set any specific limit on window area, but rather requires more efficient window U-factors or other improvements as the window area increases for any given house design. Therefore, code compliance may be easier for a starter home with small windows that are few and far between and more difficult for a "view home" with a huge window area.

Table 3.1. Energy Efficiency Measures Assumed for Current Practice and IECC Compliance

	Aurora		Springfield	
	Current Practice	**IECC**	**Current Practice**	**IECC**
Ceiling	R-30	R-38	R-30	R-30
Wall	R-13	R-13	R-13	R-13
Window U-factor	U-0.48 (no low-E)	U-0.35 (low-E)	U-0.48 (no low-E)	U-0.39 (low-E)
Floors Above Unheated Basements	R-13	R-30	R-13	R-19
Duct Insulation	None	R-8 supply, R-2 return	None	R-8 supply, R-2 return
Duct Sealing	No	Yes	No	Yes
Heating System	Gas furnace, 80% AFUE	Gas furnace, 80% AFUE	Gas furnace, 80% AFUE	Gas furnace, 80% AFUE
Cooling System	Air conditioner, 10 SEER	Air conditioner, 10 SEER	Air conditioner, 10 SEER	Air conditioner, 10 SEER

4.0 Impacts from Adopting 2000 IECC in Illinois

Our assessment of the impacts from adopting the 2000 IECC for residential buildings in Illinois includes construction costs impacts, energy savings, mortgage-related cost impacts to consumers, life-cycle cost impacts, and aggregate statewide impacts.

4.1 Construction Cost Impacts

The analysis used to determine the cost effectiveness of adopting the 2000 IECC in Illinois requires information on cost increases in insulation, duct sealing, and window measures needed to meet the code requirements. Estimating construction costs is the most difficult and uncertain step in assessing the cost effectiveness of energy codes. Costs can vary greatly depending on the builder, subcontractors, and materials and equipment suppliers. Costs are expected to decrease after the market adapts to the code requirements and the energy-efficient products required by the code become prevalent. The costs reported here include the builder's profit and represent the amount paid by the homebuyer if the buyer pays for the house in cash.

Installed costs for increased insulation were obtained from *Means Residential Cost Data--2001* (Means 2000). For floor insulation, R.S. Means provides an incremental cost of $\$0.17/ft^2$ for R-19 instead of R-11 and $\$0.50/ft^2$ for R-19 instead of R-11 (we assumed R-11 costs were equal to R-13 costs because Means did not contain an R-13 reference). For ceiling insulation, R.S. Means provides an incremental cost of $\$0.17/ft^2$ for R-38 instead of R-30.

The improvements to windows needed to achieve U-factors low enough to comply with the IECC are expected to be primarily from the addition of low-E coatings on double-pane windows. This cost is supported by a survey in Ohio that reported a cost of $\$0.65/ft^2$ to improve windows from a U-factor of about 0.50 to below 0.35 (Ohio 1996). A Building America team member estimates typical cost increases of $300 per house for windows meeting Energy Star (U-0.35 in cold climates) ratings (Edminster et al. 2000). The California Database for Energy Efficient Resources of $1.68 for adding low-E to a double-pane vinyl window (Xenergy 2001). Finally, the Northwest Energy Star Window Project reports an incremental retail cost of $\$0.89/ft^2$ from seven manufacturers to improve windows from U-0.44 to U-0.34 (Quantec 2002). We used this source to estimate costs for improving window U-factors in our analysis.

Data from NAHB and anecdotal information suggest that ductwork in unheated basements is generally not insulated or properly sealed. A homebuilder survey reported that 83% of builders in Illinois use duct tape to seal ducts (ISU 1997). Ironically, duct tape performs poorly at sealing ducts (Sherman et al. 2000). The IECC requires that ducts be sealed with welds, gaskets, mastics (adhesives), mastics-plus-embedded-fabric systems, or tapes. Tapes and mastics shall be listed and labeled in accordance with UL 181A and 181B.

One study reports a $214 cost for improved duct sealing in new homes (Hammon and Modera 1996). Numerous studies have examined duct sealing in existing homes. Typical costs for duct sealing range from $200 to $500 (Boe 1998; Xenergy 2000). Sealing and insulating ducts should be much easier and cheaper in a new home compared to an existing home because the ducts are more accessible and the contractors are already on site. We therefore used the $214 cost for sealing ducts in our analysis as required by the IECC.

We obtained duct insulation costs from R.S. Means (2000). The installed cost for 1½ in. of duct wrap insulation is $1.92/ft^2. This insulation has an out-of-package R-value of about 5. We assumed that 216 ft^2 of duct surface area would require insulation based on the floor area of the house and the unheated basement foundation (Triedler et al. 1996). The total cost for insulating the ducts to R-5 is $421. The 2001 Supplement to the 2000 IECC requires R-8 on supply ducts and R-2 on return ducts (return ducts in basements are not required to be insulated). In the 2000 IECC, supply ducts are required to be insulated to R-5. Because most of the cost for duct insulation is from the cost of labor to install the insulation, the incremental cost of R-8 instead of R-5 for supply ducts should be relatively small. Therefore, we assumed a cost of $500 to insulate ducts.

Table 4.1 shows the construction costs for energy efficiency measures required by the 2000 IECC. Note again that other combinations of improvements in energy efficiency measures can be used to comply with the 2000 IECC and might have a lower cost. For example, if a more efficient natural gas furnace is installed (an 80%-efficient furnace is assumed here), insulation levels may be lowered. Actual construction cost increases related to IECC compliance will often be different because not all new Illinois homes are built with the same energy efficiency measures assumed here. As the energy efficiency measures required by the code gain large market shares and builders find low-cost methods of meeting the code, we expect the first costs impacts of the code to drop.

Table 4.1. Construction Costs (Incremental) for IECC Energy Efficiency Measures

	Aurora	**Springfield**
Ceiling	$190	0
Window U-factor	$363	$252
Floors Above Unheated Basements	$560	$190
Duct Insulation	$500	$500
Duct Sealing	$214	$214
TOTAL	$1827	$1156

4.2 Energy Savings

We used the Energy-10 simulation tool (Sustainable Buildings Industry Council 1998) to estimate the energy savings from the building envelope improvements necessary to meet the IECC for the prototype house. The Appendix contains a printout showing the results and input assumptions for the

Energy-10 simulations. (Note that weather data was not available for Aurora in Energy-10, so we used the Chicago weather data instead.) We obtained the latest available costs for natural gas and electricity from the DOE Energy Information Administration:

- $6.74 per mcf (Midwest residential estimate) (DOE 2001a)
- 9.4 cents per kWh (Illinois residential average in August 2001) (DOE 2001b).

We quantified the savings from improvements to the duct system independently of the Energy-10 simulations. Numerous studies have shown that the energy loss from ducts passing through unconditioned spaces in houses is typically 25% or more of total heating and cooling energy use (Boe 1998; Coito et al. 1998). Much of the heat loss from ducts in an unconditioned basement will find its way back into the house (Triedler 1993). However, the use of basement ceiling insulation will actually increase the heat loss from ducts in basements to the outside, making it more important to properly seal and insulate ducts. Most of the heat loss from ducts in attics, garages, and crawl spaces is lost to the outside.

One study estimates heating and cooling savings from improved duct sealing to be 12% in new homes (Hammon and Modera 1996). Another report predicts that sealing 80% of the duct leaks in the basement and insulating the basement ducts to R-5 will produce a 10% savings in energy use (Triedler 1993). Duct sealing measures in existing homes achieved a 5% to 10% annual energy use reduction (Boe 1998). The potential for properly sealing ducts is better in a new building than in a retrofit because the ducts will be fully accessible. For this analysis, we assumed that HVAC energy costs will decrease 10% by sealing and insulating the ducts as required by the IECC. The benefits from code requirements for duct sealing (or the construction cost increases) will not be realized unless they are complied with by builders and subcontractors and enforced by code officials. (Washington State University 2001).

Table 4.2 shows the annual energy savings that will result from complying with the IECC building envelope requirements.

Table 4.2. Annual Energy Savings from Compliance with IECC

	Aurora			Springfield		
	Heating	**Cooling**	**Total**	**Heating**	**Cooling**	**Total**
Current Practice	$708	$355	$1063	$643	$469	$1112
IECC (excluding duct improvements)	$599	$292	$891	$605	$399	$1004
IECC (including duct improvements)	$539	$263	$802	$544	$359	$904
Total Savings	$169	$92	$261	$99	$110	$208
Percent Savings	24%	26%	25%	15%	23%	19%

4.3 Cash Flow: Mortgage-Related Cost Impacts

Because most houses are financed, consumers will be very interested in the financial impacts of buying a home that complies with the 2000 IECC requirements. Mortgages spread the payment for the cost of a house over a long period of time. In this analysis, we assumed a fixed-rate mortgage. We also assumed that homebuyers will deduct the interest portion of the payments from their income taxes.

The financial and economic parameters required for input to this analysis are summarized below. These parameters are used to calculate the costs and benefits of increased energy efficiency from the homeowner's perspective. We selected a relatively low down payment and a moderate federal income tax rate.

- New-home mortgage parameters:
  - 7.0% mortgage interest rate (fixed rate)
  - points and loan fees equal to 1.6% of the mortgage amount
  - 30-year loan term
  - 10% down payment.

- Other rates and economic parameters:
  - 28% marginal federal income tax, 3% state income tax
  - 1.5% property tax.

Table 4.3 shows the impacts to consumers' cash flow resulting from IECC compliance. The up-front costs include the down payment, points, and loan fees. The savings from income tax deductions for the mortgage interest will slowly decrease over time. The values shown in the table are for the first year. Table 4.3 also includes increases in annual property taxes because of the higher assessed house values. The net annual cash flow includes energy costs, mortgage payments, mortgage tax deductions, and property taxes but not the up-front costs.

Most consumers want to know when they will start saving money (accounting for all costs and benefits). The energy cost savings resulting from increased energy efficiency start as soon as the dwelling is occupied. Of more interest may be the time when homeowners have saved more money than they have paid out (including the down payment), referred to as the time to cumulative positive cash flow. Beyond this time, the net cost savings can be expected to continue to grow; thus, the shorter the length of time to positive cash flow, the more attractive investing in increased energy efficiency becomes. Table 4.3 shows the number of years until the homeowner is expected to realize a net cost savings from increased levels of energy efficiency (i.e., the cumulative savings exceed the cumulative expenditures).

Table 4.3. Impacts to Consumers' Cash Flow from Compliance with IECC

	Aurora	Springfield
Up-Front Costs	$205	$130
Energy Savings	$261	$208
Mortgage Increase	$137	$87
Income Tax Deduction Increase	$37	$23
Property Tax Increase	$20	$13
Net Annual Cash Flow (excluding up-front costs)	$141 Savings	$131 Savings
Years to Positive Cash Flow	About 1½ year	About 1 year

4.4 Life-Cycle Cost Impacts

Table 4.4 shows two measures of economic impacts from compliance with the IECC over a 30-year period for the prototype house. In the net present value, the first cost of code compliance is subtracted from the present value of energy savings over 30 years. In the benefit/cost ratio, the present value of energy savings is the numerator and the first cost of code compliance is the denominator. We assumed a nominal discount rate of 7% and an inflation rate of 3% for fuel costs.

Table 4.4. Life-Cycle Cost Impacts from Compliance with IECC

	Aurora	Springfield
Construction Cost	$1827	$1156
First Year Energy Cost Savings	$261	$208
Present Worth Factor	17.54	17.54
Present Value of Energy Savings	$4578	$3648
Net Present Value	$2751	$2492
Benefit/Cost Ratio	2.51	3.16

4.5 Aggregate Statewide Impacts

All results discussed in previous sections have been at the individual house-by-house level. In Table 4.5, the results are aggregated to a statewide total, assuming a code would be adopted statewide in 2003. The results for the prototype houses in Aurora and Springfield were averaged together to obtain an estimated state average. The Department of Census data on building permits reports that about 52,000 residential units were built in 2000 (U.S. Census Bureau 2001). Of these, 73% of new dwellings were single-family houses and 2% were duplexes. The remaining 25% were multifamily. To approximate the code impacts on multifamily dwellings, the impacts on the 2,240-ft^2 prototype house were reduced by 50%. In Table 4.5, the "Annual" results are the first year savings for the 52,000 units that we assume will be built each year. The cumulative savings in 2010 and 2020 account for the fact that each year, more and more buildings will be built under the code and that annual savings for individual buildings will accumulate over multiple years.

Pollutant emission rates for electricity were taken from DOE Energy Information Administration data for Illinois (DOE 2001c). Pollutant emission rates for natural gas are the default values from the Energy-10 software.

Table 4.5. Aggregate Statewide Impacts from Compliance with IECC

	Annual	**Cumulative**	
		2010	**2020**
Energy Cost Savings	$10.7 Million	$458 Million	$2.7 Billion
Electricity Savings	38 Million kWh	1400 Million kWh	6500 Million kWh
Natural Gas Savings	423 GBtu	15 TBtu	72.3 TBtu
SO_2 Reduction (tons)	165 tons	5900 tons	28000 tons
NO_x Reduction (tons)	116 tons	4200 tons	20000 tons
CO_2 Reduction (tons)	46,400 tons	1.7 million tons	7.9 million tons

5.0 Conclusion

If the IECC were adopted by jurisdictions in the state of Illinois, or statewide, substantial improvements is expected in the energy efficiency of residential buildings. While the initial cost of construction will rise, energy bills will be substantially reduced. Construction cost increases and energy savings will vary depending on many factors, including location, fuel prices, house size and characteristics, material and labor costs, and the energy efficiency measures used to comply with the 2000 IECC. Our analysis indicates that construction costs for the energy efficiency measures evaluated in our study would cost approximately $1,827 and $1156 in Aurora and Springfield, respectively.

Our analysis concludes that homes built to meet the 2000 IECC requirements will save Illinois homeowners money by reducing long-term energy costs by far more than the construction-related cost increases. Annual heating and air conditioning cost savings for homes complying with the IECC in Illinois would typically be around 20%, or about $210-260 a year. Homeowners should realize a net positive cash flow within a few years after accounting for the effects of a typical mortgage. For these types of impacts to be achieved, an effort will be required to assist builders and subcontractors to comply with the code, and code officials to enforce it.

Our analysis also shows a significant reduction in pollutant emissions. An annual reduction in pollution from sulfur dioxide is estimated to be 165 tons, resulting in cumulative reductions of 5900 tons in 2010 and 28,000 tons in 2020. Similarly nitrogen oxide reductions of 116 tons annually and cumulatively 4200 tons in 2010 and 20,000 tons in 2020 are estimated. Finally, carbon dioxide reductions of 46,400 tons annual are estimated and cumulatively 1.7 million tons in 2010 and 7.9 million tons in 2020.

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Attachment 1

MEC*check* - Aurora

____
Permit Number

MEC*check* Compliance Report
2000 IECC

MEC*check* Software Version 3.3 Release 1

____
Checked By/Date

Data filename: C:\Program Files\MECcheck3.3\aurora.cck

CITY: Aurora
STATE: Illinois
HDD: 6699
CONSTRUCTION TYPE: Single Family

DATE: 02/08/02

COMPLIANCE: Passes

Maximum UA = 346
Your Home = 344
0.6% Better Than Code

	Gross Area or Perimeter	Cavity R-Value	Cont. R-Value	Glazing or Door U-Factor	UA
Ceiling 1: Flat Ceiling or Scissor Truss	1120	38.0	0.0		34
Wall 1: Wood Frame, 16" o.c.	2176	13.0	0.0		149
Window 1: Vinyl Frame, Double Pane	314			0.350	110
Door 1: Solid	40			0.350	14
Floor 2: All-Wood Joist/Truss, Over Unconditioned Space	1120	30.0	0.0		37

Furnace 1: Forced Hot Air, 80 AFUE
Air Conditioner 1: Electric Central Air, 10 SEER

COMPLIANCE STATEMENT: The proposed building design described in this Compliance Report and in the MECcheck Inspection Checklist is consistent with the building plans, specifications, and other calculations submitted with the permit application. The proposed building has been designed to meet the 2000 IECC requirements in MEC*check* Version 3.3 Release 1.

Builder/Designer____ Date________________

Attachment 2

MEC*check* - Springfield

____
Permit Number

MEC*check* Compliance Report
2000 IECC

MEC*check* Software Version 3.3 Release 1

Data filename: C:\Program Files\MECcheck3.3\springfield.cck

____
Checked By/Date

CITY: Springfield
STATE: Illinois
HDD: 5688
CONSTRUCTION TYPE: Single Family

DATE: 02/08/02

COMPLIANCE: Passes

Maximum UA = 380
Your Home = 377
0.8% Better Than Code

	Gross Area or Perimeter	Cavity R-Value	Cont. R-Value	Glazing or Door U-Factor	UA
Ceiling 1: Flat Ceiling or Scissor Truss	1120	30.0	0.0		39
Wall 1: Wood Frame, 16" o.c.	2176	13.0	0.0		149
Window 1: Vinyl Frame, Double Pane	314			0.390	122
Door 1: Solid	40			0.350	14
Floor 2: All-Wood Joist/Truss, Over Unconditioned Space	1120	19.0	0.0		53
Furnace 1: Forced Hot Air, 80 AFUE					
Air Conditioner 1: Electric Central Air, 10 SEER					

COMPLIANCE STATEMENT: The proposed building design described in this Compliance Report and in the MECcheck Inspection Checklist is consistent with the building plans, specifications, and other calculations submitted with the permit application. The proposed building has been designed to meet the 2000 IECC requirements in MEC*check* Version 3.3 Release 1.

Builder/Designer____ Date_______________

Attachment 3

Energy-10 Report - Aurora – IECC

Chicago SF
Energy-10 Summary Page
Variant: AutoBuild Shoebox
Comments: 2240 sq ft, unheated bsmt
Varient 3 is IECC
U-0.35, R-30 floor, R-13 walls
R-38 ceilings (2/7/02 version)

Feb 07, 2002
Weather file: chicago.et1
Saved as C:\E10-1.3\CHICAGO, Var. 3

IECC

Description:		
Floor Area, ft²	2240.0	6600.0
Surface Area, ft²	4416.0	11320.0
Volume, ft³	17920.0	52800.0
Surface Area Ratio	1.07	1.34
Total Conduction UA, Btu/h-F	352.1	540.8
Average U-value, Btu/hr-ft²-F	0.080	0.048
Wall Construction	r-13, R=11.8	2 x 6 frame, R=17.7
Roof Construction	attic, r-38, R=31.8	attic, r-30, R=23.2
Floor type, insulation	Crawl Space, Reff=33.0	Slab on Grade, Reff=55.9
Window Construction	.35u-.4shgc-19.63sqft, U=0.35,etc	4060 super, wood, U=0.36
Window Shading	<none>	shade type 1
Wall total gross area, ft²	2176	4720
Roof total gross area, ft²	1120	3300
Ground total gross area, ft²	1120	3300
Window total gross area, ft²	314	207
Windows (N/E/S/W:Roof)	4/4/4/4:0	4/1/2/2:0
Glazing name	.40shgc-.35u, U=0.35	.40shgc-.35u, U=0.35
Operating parameters for zone 1		
HVAC system	DX Cooling with Gas Furnace	DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool),kBtuh	50/28/38	56/36/48
Rated Air Flow/MOOA,cfm	1312/0	2212/0
Heating thermostat	72.0 °F, no setback	72.0 °F, setback to 67.0 °F
Cooling thermostat	75.0 °F, no setup	75.0 °F, setup to 80.0 °F
Heat/cool performance	eff=80,EER=8.9	eff=95,EER=13.0
Economizer?/type	no/NA	yes/electronic type A
Duct leaks/conduction losses, total %	8/5	2/0
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/0.66/0.36	0.20/0.04/0.66/0.36
Added mass?	none	3300 ft², 8in cmu
Daylighting?	no	yes, continuous dimming
Infiltration, in²	ACH=0.4	ELA=169.9
Results: (Energy cost: 0.656 \$/Therm, 0.094 \$/kWh, 0.000 \$/kW)		
Simulation dates	01-Jan to 31-Dec	00-Jan to 00-Jan
Simulation status, Thermal/DL	valid/NA	missing/NA
Energy use, kBtu	142097	NA
Energy cost, \$	1720	NA
Saved by daylighting, kWh	NA	NA
Total Electric, kWh	11010	NA
Internal/External lights, kWh	1760/192	NA
Heating/Cooling/Fan, kWh	0/2705/1017	NC
Hot water/Other, kWh	0/5336	NC
Peak Electric, kW	4.9	NA
Fuel, hw/heat/total, kBtu	21912/82616/104528	NC
Emissions, CO2/SO2/NOx, lbs	4465/88/46	NA

610 H
407 C

kWh
11817
- 11010
807

MBtu
97174
82616
14558

Heat ⇒ 82.6 × 656 = \$542
610 × .094 = \$57
\$599

Cool
2705 + 407 = 3112
× .094
\$292

\$109 → \$172 ← \$63

Attachment 4

Energy-10 Report - Aurora – Current Practice

Chicago SF
Energy-10 Summary Page
Variant: AutoBuild Shoebox
Comments: 2240 sq ft, unheated bsmt
Varient 1 is current practice
U-0.48, R-13 floor, R-13 walls
R-30 ceilings

Feb 07, 2002
Weather file: chicago.et1
Saved as C:\E10-1.3\CHICAGO, Var. 1

Current Practice

Description:		
Floor Area, ft²	2240.0	6600.0
Surface Area, ft²	4416.0	11320.0
Volume, ft³	17920.0	52800.0
Surface Area Ratio	1.07	1.34
Total Conduction UA, Btu/h-F	421.5	540.8
Average U-value, Btu/hr-ft²-F	0.095	0.048
Wall Construction	r-13, R=11.8	2 x 6 frame, R=17.7
Roof Construction	attic, r-30, R=23.2	attic, r-30, R=23.2
Floor type, insulation	Crawl Space, Reff=22.6	Slab on Grade, Reff=55.9
Window Construction	.48u-.55 shgc-19.63sqft, U=0.48,etc	4060 super, wood, U=0.36
Window Shading	<none>	shade type 1
Wall total gross area, ft²	2176	4720
Roof total gross area, ft²	1120	3300
Ground total gross area, ft²	1120	3300
Window total gross area, ft²	314	207
Windows (N/E/S/W:Roof)	4/4/4/4:0	4/1/2/2:0
Glazing name	.48u-.55shgc, U=0.48	.40shgc-.35u, U=0.35
Operating parameters for zone 1		
HVAC system	DX Cooling with Gas Furnace	DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool),kBtuh	58/34/46	56/36/48
Rated Air Flow/MOOA,cfm	1606/0	2212/0
Heating thermostat	72.0 °F, no setback	72.0 °F, setback to 67.0 °F
Cooling thermostat	75.0 °F, no setup	75.0 °F, setup to 80.0 °F
Heat/cool performance	eff=80,EER=8.9	eff=95,EER=13.0
Economizer?/type	no/NA	yes/electronic type A
Duct leaks/conduction losses, total %	8/5	2/0
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/0.66/0.36	0.20/0.04/0.66/0.36
Added mass?	none	3300 ft², 8in cmu
Daylighting?	no	yes, continuous dimming
Infiltration, in²	ACH=0.4	ELA=169.9
Results: (Energy cost: 0.656 $/Therm, 0.094 $/kWh, 0.000 $/kW)		
Simulation dates	01-Jan to 31-Dec	00-Jan to 00-Jan
Simulation status, Thermal/DL	valid/NA	missing/NA
Energy use, kBtu	159410	NA
Energy cost, $	1892	NA
Saved by daylighting, kWh	NA	NA
Total Electric, kWh	11817	NA
Internal/External lights, kWh	1760/192	NA
Heating/Cooling/Fan, kWh	0/3272/1257	NC
Hot water/Other, kWh	0/5336	NC
Peak Electric, kW	5.8	NA
Fuel, hw/heat/total, kBtu	21912/97174/119086	NC
Emissions, CO2/SO2/NOx, lbs	4815/95/50	NA

754 H
503 C

Heat
97.2 × 6.56 = $637
754 × .094 = $71
$708

Cool
3272 + 503 = 3775
× 0.094
$355

Attachment 5

Energy-10 Report - Springfield – IECC

Springfield IL SF
Energy-10 Summary Page
Variant: AutoBuild Shoebox
Comments: Varient 3 is IECC
U-0.39, R-19 floor, R-13 walls,
R-30 ceilings

Feb 07, 2002
Weather file: springil.et1
Saved as C:\E10-1.3\SPRINGFI, Var. 3

IECC

Description:		
Floor Area, ft²	2240.0	6600.0
Surface Area, ft²	4416.0	11320.0
Volume, ft³	17920.0	52800.0
Surface Area Ratio	1.07	1.34
Total Conduction UA, Btu/h-F	385.5	540.8
Average U-value, Btu/hr-ft²-F	0.087	0.048
Wall Construction	r-13, R=11.8	2 x 6 frame, R=17.7
Roof Construction	attic, r-30, R=23.2	attic, r-30, R=23.2
Floor type, insulation	Crawl Space, Reff=26.8	Slab on Grade, Reff=55.9
Window Construction	.39u-.4shgc-19.63sqft, U=0.39,etc	4060 super, wood, U=0.36
Window Shading	<none>	shade type 1
Wall total gross area, ft²	2176	4720
Roof total gross area, ft²	1120	3300
Ground total gross area, ft²	1120	3300
Window total gross area, ft²	314	207
Windows (N/E/S/W:Roof)	4/4/4/4:0	4/1/2/2:0
Glazing name	.40shgc-.39u, U=0.39	.40shgc-.35u, U=0.35
Operating parameters for zone 1		
HVAC system	DX Cooling with Gas Furnace	DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool),kBtuh	52/30/40	56/36/48
Rated Air Flow/MOOA,cfm	1372/0	2212/0
Heating thermostat	72.0 °F, no setback	72.0 °F, setback to 67.0 °F
Cooling thermostat	75.0 °F, no setup	75.0 °F, setup to 80.0 °F
Heat/cool performance	eff=80,EER=8.9	eff=95,EER=13.0
Economizer?/type	no/NA	yes/electronic type A
Duct leaks/conduction losses, total %	8/5	2/0
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/0.66/0.36	0.20/0.04/0.66/0.36
Added mass?	none	3300 ft², 8in cmu
Daylighting?	no	yes, continuous dimming
Infiltration, in²	ACH=0.4	ELA=169.9
Results: (Energy cost: 0.656 $/Therm, 0.094 $/kWh, 0.000 $/kW)		
Simulation dates	01-Jan to 31-Dec	00-Jan to 00-Jan
Simulation status, Thermal/DL	valid/NA	missing/NA
Energy use, kBtu	145893	NA
Energy cost, $	1832	NA
Saved by daylighting, kWh	NA	NA
Total Electric, kWh	12224	NA
Internal/External lights, kWh	1760/192	NA
Heating/Cooling/Fan, kWh	0/3775/1162	NC
Hot water/Other, kWh	0/5336	NC
Peak Electric, kW	5.4	NA
Fuel, hw/heat/total, kBtu	21912/82269/104181	NC
Emissions, CO2/SO2/NOx, lbs	4919/98/51	NA

697 H
465 C

T&T kWh
13098
-12224
874

Tot MBtu
86296
-82269
4,027

Heat
82.3 x 6.56 = 540
697 x .094 = 65
$605

Cool
3775+465 = 4240
x .094
$399

$38 $108 $70

Attachment 6

Energy-10 Report - Springfield – Current Practice

Springfield IL SF
Energy-10 Summary Page
Variant: AutoBuild Shoebox
Comments: 2240 sq ft, unheated bsmt
Varient 1 is current practice
U-0.48, R-13 floor, R-13 walls
R-30 ceilings

Feb 07, 2002
Weather file: springil.et1
Saved as C:\E10-1.3\SPRINGFI, Var. 1

Curr Practice

Description:		
Floor Area, ft²	2240.0	6600.0
Surface Area, ft²	4416.0	11320.0
Volume, ft³	17920.0	52800.0
Surface Area Ratio	1.07	1.34
Total Conduction UA, Btu/h-F	421.5	540.8
Average U-value, Btu/hr-ft²-F	0.095	0.048
Wall Construction	r-13, R=11.8	2 x 6 frame, R=17.7
Roof Construction	attic, r-30, R=23.2	attic, r-30, R=23.2
Floor type, insulation	Crawl Space, Reff=22.6	Slab on Grade, Reff=55.9
Window Construction	.48u-.55 shgc-19.63sqft, U=0.48,etc	4060 super, wood, U=0.36
Window Shading	<none>	shade type 1
Wall total gross area, ft²	2176	4720
Roof total gross area, ft²	1120	3300
Ground total gross area, ft²	1120	3300
Window total gross area, ft²	314	207
Windows (N/E/S/W:Roof)	4/4/4/4:0	4/1/2/2:0
Glazing name	.48u-.55shgc, U=0.48	.40shgc-.35u, U=0.35

Operating parameters for zone 1		
HVAC system	DX Cooling with Gas Furnace	DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool),kBtuh	56/35/47	56/36/48
Rated Air Flow/MOOA,cfm	1609/0	2212/0
Heating thermostat	72.0 °F, no setback	72.0 °F, setback to 67.0 °F
Cooling thermostat	75.0 °F, no setup	75.0 °F, setup to 80.0 °F
Heat/cool performance	eff=80,EER=8.9	eff=95,EER=13.0
Economizer?/type	no/NA	yes/electronic type A
Duct leaks/conduction losses, total %	8/5	2/0
Peak Gains; IL,EL,HW,OT; W/ft²	0.20/0.04/0.66/0.36	0.20/0.04/0.66/0.36
Added mass?	none	3300 ft², 8in cmu
Daylighting?	no	yes, continuous dimming
Infiltration, in²	ACH=0.4	ELA=169.9

Results: (Energy cost: 0.656 $/Therm, 0.094 $/kWh, 0.000 $/kW)

Simulation dates	01-Jan to 31-Dec	00-Jan to 00-Jan
Simulation status, Thermal/DL	valid/NA	missing/NA
Energy use, kBtu	152902	NA
Energy cost, $	1941	NA
Saved by daylighting, kWh	NA	NA
Total Electric, kWh	13098	NA
Internal/External lights, kWh	1760/192	NA
Heating/Cooling/Fan, kWh	0/4453/1357	NC
Hot water/Other, kWh	0/5336	NC
Peak Electric, kW	6.2	NA
Fuel, hw/heat/total, kBtu	21912/86296/108208	NC
Emissions, CO2/SO2/NOx, lbs	5260/105/55	NA

814 H
543 C

Heat
86.3 × 6.56 = 566
814 × .094 = 77
$ 643

Cool
4453 + 543 = 4996
× .094
$469