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**Subject** Focus on Energy Evaluation

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**ACES New Construction Baseline Review**

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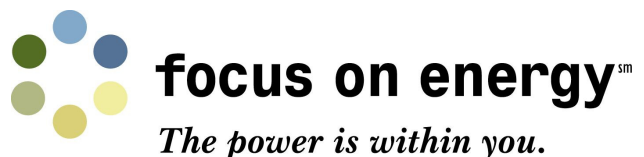
At the end of 2009, the Energy Center of Wisconsin (ECW) completed a baseline study of new construction projects in Wisconsin.<sup>1</sup> This research effort characterized building design practices for commercial (classified as assembly, business, education, factory, or retail) and multifamily buildings after updates to the Wisconsin Energy Code that went into effect March 1, 2008. The main objective was to understand whether there were measures for which standard practices were typically above or below the new code specifications. This was accomplished by through an examination of building plans and other design information submitted to the State of Wisconsin and the City of Madison.

The collected data were from buildings that were either expected to be in compliance with the new Wisconsin Energy Code and were new construction or major renovation projects of at least 15,000 square feet. Data were gathered on many energy-related building features, such as insulation levels, window properties, HVAC equipment efficiency, and lighting efficiency.

Data were extracted from the technical planning documents for energy-related building features for 103 buildings, 22 of which were multi-family buildings. Complete information was not available for all of the building or equipment specifications at the time the plans were reviewed. Additional data on lighting specifications were collected for 260 buildings after March 2, 2009, to address the fact that lighting compliance documentation was not required to be submitted to the state prior to March 2, 2009.

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<sup>1</sup> Keith Swartz, Energy Center of Wisconsin. *2008 New Construction Program Baseline Study for Focus on Energy*. November 2009.



The baseline assumptions used by the program are intended to approximate standard design practice for buildings in Wisconsin. Energy savings for new construction measures and buildings are based on a comparison of expected consumption using actual build specifications and expected consumption for the same building or measure using baseline assumptions.

The Wisconsin Energy Code that went into effect on March 1, 2008,<sup>2</sup> allowed two different compliance paths: (1) the 2006 International Energy Conservation Code (IECC) with Wisconsin amendments or (2) the 2004 edition of ASHRAE Standard 90.1 *Energy Standard for Buildings Except Low-Rise Residential Buildings*<sup>3</sup>. The program baseline requirements followed the minimum compliance requirements for the 2006 IECC<sup>4</sup>.

The results of this study were used to inform baseline assumptions for calculating energy savings for new construction measures. In the interim, Wisconsin has been working towards another update to the building codes. These updates will most likely be based on the 2009 IECC (with amendments) and the ASHRAE Standard 90.1-2007, based on the statement "WI is in the process of adopting the 2009 IECC with amendments. Adoption expected to be effective sometime around July 2010."<sup>5</sup> The codes adopted in 2008 were largely based on the 2006 IECC and the ASHRAE Standard 90.1-2004. We understand that, realistically, the adoption may not occur in July 2010; however, we are confident that the ACES program staff are very aware of pending changes to the code. The evaluation recommendations presented below are in anticipation of these changes to the adoption of the new code in the near future. Policy still needs to be set regarding how the program should respond once these pending code changes are put in place.

Table 1 presents information extracted from the study which was specific to multi-family buildings. The columns in the table are as follows:

- **Measure.** A description of the measure for which information was gathered on some of the 22 multifamily buildings included in the ECW study
- **Existing baseline value.** The baseline value that was used prior to the study for calculating energy impacts from implementing high efficiency equipment in buildings participating in the ACES New Construction program
- **ECW recommendation.** A recommended baseline value to be used for the 2010 program year for calculating energy impacts from implementing high efficiency equipment in buildings participating in the ACES New Construction program

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<sup>2</sup> Department of Commerce. *Wisconsin Administrative Code*. "Chapter COMM 63: Energy Conservation." April 2008.

<sup>3</sup> ANSI/ASHRAE/IESNA Standard 90.1-2004, December 30, 2004, *Energy Standard for Buildings Except Low-Rise Residential Buildings*.

<sup>4</sup> International Code Council. *2006 International Energy Conservation Code*. "Chapter 4: Residential Energy Efficiency" and "Chapter 5: Commercial Energy Efficiency." March 1, 2006.

<sup>5</sup> [http://www.energycodes.gov/implement/state\\_codes/state\\_status.php?state\\_AB=WI](http://www.energycodes.gov/implement/state_codes/state_status.php?state_AB=WI).

- **Evaluation recommendation.** A recommendation for baseline values to be adopted in the future (late 2010 or 2011 program year) for calculating energy impacts from implementing high efficiency equipment in buildings participating in the ACES New Construction program.

Table 1. ACES New Construction Baseline Review Table

Measure	Existing Baseline Value	ECW Recommendation	Evaluation Recommendation
R-values for insulation of aboveground mass walls	R-15	No changes are recommended to the baseline values for multifamily because the average values were not significantly better than the existing baseline. In fact, many of the average values were below baseline. For many buildings the lack of insulation in walls was compensated for with additional insulation in the roof.	2006 IECC specifies R-9.5, and 2009 IECC specifies R-13.3. R-15 is clearly too high to reflect current practice, even though ASHRAE 90.1-2007 recommends R-15.2ci. Recommend R-13.3 as per 2009 IECC.
R-values for insulation of metal building walls	The existing baseline value is two layers of R-13, the first one compressed at the structural elements. The overall effective R-value depends on the spacing of structural elements that compress the insulation. A common U-value in COMcheck for the budget buildings was U-0.057, which corresponds to an effective R-value of R-17.5	No changes are recommended to the baseline value for multifamily buildings because there were no multifamily metal buildings in the study.	None
R-values for insulation of metal-framed walls	R-8 continuous insulation and R-19 cavity insulation; for nominal 6-inch studs with 24-inch spacing, the overall equivalent R-value is R-18.5.	No changes are recommended to the baseline value for multifamily buildings because the average values were not significantly better than the existing baseline.	None
R-values for insulation of wood-framed walls	R-0 continuous insulation and R-19 cavity insulation; for nominal 6-inch studs with 24-inch spacing, the overall equivalent R-value is R-15.4.	No changes are recommended to the baseline value for multifamily buildings because the average values were not significantly better than the existing baseline.	2009 IECC and ASHRAE 90.1-2007 specify minimum values of R-7.5ci + R-13 cavity. Assembly value: R15.6. Recommend increasing baseline to R-15.6
R-values for insulation of belowgrade walls	R-10 continuous insulation	No changes are recommended to the baseline value for multifamily buildings because the average values were not significantly better than the existing baseline.	Agreed, 2009 IECC and ASHRAE 90.1-2007 specify a minimum value of R-7.5ci, but the sample data clearly indicates common practice is higher.
R-values for roof insulation above deck	R-49	No changes are recommended to the baseline value for multifamily buildings. Although the average R-values for several building types were more than 10% better than code, many building designs compensated for low wall insulation with additional roof insulation.	2009 IECC and ASHRAE 90.1-2007 specify a minimum value of R-20ci, but the sample data suggests common practice is higher. Suggest lowering baseline to R-38 for buildings that meet or exceed the wall baseline and keep R-49 for those that do not.

Measure	Existing Baseline Value	ECW Recommendation	Evaluation Recommendation
R-values for roof insulation of metal buildings	R-49	No changes are recommended to the baseline value for either commercial or multifamily buildings due to the limited number of data points. Although the average R-values for several building types were more than 10% better than code, many building designs compensated for low wall insulation with additional roof insulation.	2009 IECC and ASHRAE 90.1-2007 specify a minimum value of R-13 + R-19 but the sample data suggests common practice is higher. Suggest lowering baseline to R-38 for buildings that meet or exceed the wall baseline and keep R-49 for those that do not.
R-values for roof insulation in attics	R-49 (R-47.6 effective overall)	No changes are recommended to the baseline value for multifamily buildings because the average values were not significantly better than the existing baseline.	2009 IECC and ASHRAE 90.1-2007 specify a minimum value of R38, but the sample data suggests common practice is higher. Suggest lowering baseline to R-40 only for buildings that meet or exceed the wall baseline and keep R-49 for those that do not..
R-values for insulation in an exposed joist floor	R-19	No changes are recommended to the baseline value for either multifamily buildings due to the limited number of data points and an outlier from the Madison area.	2006 IECC, 2009 IECC and ASHRAE 90.1-2007 all specify a minimum value of R-30, which agrees with the sample data average despite the small sample size. Suggest increasing the baseline to R-30.
R-values for heated slab perimeter insulation	R-15 -- The average R-values are weighted based on perimeter length instead of area.	No changes are recommended to the baseline value for either multifamily because the average values were not significantly better than the existing baseline.	The efficacy of perimeter insulation is dependent not only on the R-value, but also on the depth (or distance outward) to which it is installed. 2006 IECC specifies a minimum of R-10 for 36 inches below grade. ASHRAE 90-1-2007 and 2009 IECC specify R-20 for 48in below grade. The combination of R-value and depth can be captured in the F-factor (BTU/h x ft x °F). The 2006 IECC specification translates to an F-0.638. (See chart or calculation tab for others). Recommend setting baseline at F-0.654
R-values for unheated slab perimeter insulation	R-10 -- The average R-values are weighted based on perimeter length instead of area.	No changes are recommended to the baseline value for multifamily buildings because the average values were not significantly better than the existing baseline.	The efficacy of perimeter insulation is dependent not only on the R-value, but also on the depth (or distance outward) to which it is installed. ASHRAE 90-1-2007 and 2009 IECC specify R15 for 24in below grade (2006 IECC makes no recommendation). The combination of R-value and depth can be captured in a F-factor (BTU/h x ft x °F). The specification translates to an F-0.767 Recommend setting baseline at F-0.767
U-values for swinging opaque doors	There is no code requirement regarding door U-values for multifamily buildings.	For multifamily buildings, a value of U-0.5 is recommended.	Agreed, U-0.5 corresponds to the current recommendations of ASHRAE 90-1-2007 and 2009 IECC

Measure	Existing Baseline Value	ECW Recommendation	Evaluation Recommendation
U-values for nonswinging opaque doors	There is no code requirement regarding door U-values for multifamily buildings.	The recommended value for multifamily buildings is U-0.5 to be consistent with commercial buildings. The U-value in the multifamily building is suspected to be an error in the COMcheck report. That U-value is more typical for walls than for doors.	Agreed, U-0.5 corresponds to the current recommendations of ASHRAE 90-1-2007 and 2009 IECC
U-values for glass entrance doors	U-0.35	No change is recommended to the baseline value for multifamily buildings because the average value is worse than code.	Agreed, ASHRAE 90-1-2007 and 2009 IECC specify U-0.8, but the sample data clearly indicate that common practice is lower.
U-values for metal-framed windows	U-0.35	No change is recommended to the baseline value for commercial or multifamily buildings because the average values are not significantly better than the current baseline.	Agreed, ASHRAE 90-1-2007 and 2009 IECC specify U-0.45 and U-0.40, but the sample data clearly indicate that common practice is lower.
U-values for nonmetal-framed windows	U-0.35	No change is recommended for multifamily buildings because the average value is not significantly better than the existing baseline.	Agreed, this baseline corresponds to ASHRAE 90-1-2007 and 2009 IECC specifications.
U-values for skylights	U-0.9 for plastic and U-0.6 for glass	No change is recommended to the baseline values for multifamily buildings due to the limited number of data points.	None
Solar heat gain coefficients for glass entrance doors	The Wisconsin Energy Code has no limitation regarding SHGC for multifamily buildings.	A value of SHGC-0.5 is recommended for multifamily buildings.	ASHRAE 90-1-2007 and 2009 IECC specify SHGC-0.4 for glass entrance doors and windows in climate region 6 with PF<.25, and 0.45 in climate region 7. This corresponds closely to the sample data results.
Solar heat gain coefficients for metal-framed windows	The Wisconsin Energy Code has no limitation regarding SHGC for multifamily buildings.	A value of SHGC-0.5 is recommended for multifamily.	Recommend the baseline be set at SHGC-0.45 with the baseline calculated as an area-weighted average of all glazing. This allows higher SHGC windows to be used in southern-facing walls (to maximize solar gain in winter) and lower SHGC windows on the others where solar gain is minimal during winter but unwanted during cooling season).
Solar heat grain coefficients for nonmetal-framed windows	The Wisconsin Energy Code has no limitation regarding SHGC for multifamily buildings.	A value of SHGC-0.5 is recommended for multifamily buildings.	Recommend the baseline be set at SHGC-0.45 with the baseline calculated as an area-weighted average of all glazing. This allows higher SHGC windows to be used in southern-facing walls (to maximize solar gain in winter) and lower SHGC windows on the others where solar gain is minimal during winter but unwanted during cooling season).

Measure	Existing Baseline Value	ECW Recommendation	Evaluation Recommendation
Solar heat gain coefficients for skylights	The Wisconsin Energy Code has no limitation regarding SHGC for multifamily buildings.	A value of SHGC-0.5 is recommended for multifamily buildings to be consistent with other fenestration types.	PA recommends a baseline value of SHGC-0.5
Efficiencies of gas-fired hot water boilers	80%	No change is recommended to the baseline values for either commercial or multifamily buildings due to the limited number of data points. Approximately half of the boilers were condensing and half were not condensing.	2006 IECC, 2009 IECC and ASHRAE 90.1-2007 all specify a minimum value of 80%. A study of the Boiler market in the 2008 ACES: Default Deemed Savings Review suggests the common practice averages closer to 82%. Recommend raising baseline to 82%
Efficiencies (AFUE) of residential style gas-fired furnaces	78% AFUE	The baseline value is recommended to be changed to 90% AFUE for commercial and multifamily buildings. Although there are relatively few data points, nearly all of the furnaces were condensing furnaces.	Agreed, 2006 IECC, 2009 IECC and ASHRAE 90.1-2007 all specify a minimum value of 70% AFUE, but the sample suggests current practice is higher.
Efficiencies (SEER) of split system air conditioners smaller than 65 MBH	13 SEER	No change is recommended for either commercial or multifamily buildings because the average values are not significantly better than the existing baseline.	Agreed, 2009 IECC and ASHRAE 90.1-2007 specify a minimum 13.0 SEER.
Split system air conditioners 65-135 MBH	10.3 EER	No change is recommended to the baseline values for either commercial or multifamily buildings due to the limited number of data points.	2009 IECC and ASHRAE 90.1-2007 specify a minimum 11.2 SEER. Recommend increasing baseline to 11.2 SEER to be consistent with above.
Split system air conditioners 135-240 MBH	9.7 EER	No change is recommended to the baseline values for either commercial or multifamily buildings due to the limited number of data points.	2009 IECC and ASHRAE 90.1-2007 specify a minimum 11.0 SEER. Recommend increasing baseline to 11.0 SEER to be consistent with above.
Efficiencies (EER) of split system air conditioners 240-760 MBH	9.5 EER	No change is recommended to the baseline values for either commercial or multifamily buildings due to the limited number of data points.	None
Split system air conditioners larger than 760 MBH	9.2 EER	No change to the baseline values is recommended for either commercial or multifamily buildings due to the limited number of data points.	2009 IECC and ASHRAE 90.1-2007 specify a minimum 10.0 SEER. Recommend increasing baseline to 10.0 SEER to be consistent with above.
Efficiencies (SEER) of unitary air conditioning units smaller than 65 MBH	13 SEER	No change is recommended to the baseline value for multifamily buildings due to the limited number of data points.	Agreed, 2009 IECC and ASHRAE 90.1-2007 specify a minimum 13.0 SEER.

Measure	Existing Baseline Value	ECW Recommendation	Evaluation Recommendation
Efficiencies (EER) of unitary air conditioning units 65-135 MBH	10.3 EER	No change is recommended for multifamily buildings due to the limited number of data points.	2009 IECC and ASHRAE 90.1-2007 specify a minimum 11.2 SEER. Recommend increasing baseline to 11.2 SEER to be consistent with above.
Efficiencies (EER) of unitary air conditioning units 135-240 MBH	9.7 EER	No change is recommended for multifamily buildings due to the limited number of data points.	2009 IECC and ASHRAE 90.1-2007 specify a minimum 11.0 SEER. Recommend increasing baseline to 11.0 SEER to be consistent with above.
Efficiencies (EER) of unitary air conditioning units 240-760 MBH	9.5 EER	No change is recommended for multifamily buildings due to the limited number of data points.	2009 IECC and ASHRAE 90.1-2007 specify a minimum 10.0 SEER. Recommend increasing baseline to 10.0 SEER to be consistent with above.
Efficiencies (EER) of unitary air conditioning units larger than 760 MBH	9.2 EER	No change is recommended for multifamily buildings due to the limited number of data points.	2009 IECC and ASHRAE 90.1-2007 specify a minimum 9.7 SEER. Recommend increasing baseline to 9.7 SEER to be consistent with above.
Efficiencies for packaged terminal air conditioners 7.6 MBH cooling capacity and smaller	10.9 EER	No change to the baseline value is recommended for either commercial or multifamily buildings due to the limited number of data points.	Agreed, This baseline corresponds to the minimum specified by 2009 IECC and ASHRAE 90-1-2007 for units sized at 7.6 MBTUH
Efficiencies for packaged terminal air conditioners 12 MBH cooling capacity	9.9 EER	No change to the baseline value is recommended for either commercial or multifamily buildings due to the limited number of data points.	Agreed, 2009 IECC and ASHRAE 90-1-2007 specify 9.7 SEER for units sized at 12 MBTUH, but sample data suggests common practice may be higher.
Water-cooled dual centrifugal chiller with an efficiency of 5.43 COP (0.647 kW/ton) at full load and 7.26 COP (0.484 kW/ton) NPLV	5.55 COP and 5.55 IPLV	No change to the baseline value is recommended for either commercial or multifamily buildings due to the limited number of data points.	This value corresponds to the minimum efficiency requirements of 2006 IECC for centrifugal chillers between 150 and 300 tons. The 2009 IECC and ASHRAE 90-1-2007 raise the IPLV to 5.9. Recommend increasing the IPLV to 5.9
Air cooled chillers smaller than 150 tons	2.8 COP	No change to the baseline value is recommended for either commercial or multifamily buildings due to the limited number of data points.	This value corresponds to the minimum efficiency requirements of 2006 IECC for air-cooled chillers <150tons. The 2009 IECC and ASHRAE 90-1-2007 raise the IPLV from 2.8 to 3.98 and 3.05 respectively. Recommend the current full load baseline but with an IPLV of 3.05.
Air cooled chillers larger than 150 tons	2.5 COP	No change to the baseline value is recommended for either commercial or multifamily buildings due to the limited number of data points.	This value corresponds to the minimum efficiency requirements of 2006 IECC for air-cooled chillers >150tons. The 2009 IECC and ASHRAE 90-1-2007 raise the ILPV from 2.5 to 3.74 and 3.05 respectively and the full load COP to 2.8. Recommend a baseline of 2.8 COP with IPLV of 3.05

Measure	Existing Baseline Value	ECW Recommendation	Evaluation Recommendation
Ground source heat pumps	13.4 EER for cooling and 3.6 COP for heating	No change to the baseline value is recommended for either commercial or multifamily buildings due to the limited number of data points.	Agreed, This baseline corresponds to the minimum specified by 2009 IECC and ASHRAE 90-1-2007 for GSHPs
Water source heat pumps	11.2 EER for cooling and 4.2 COP for heating	No change to the baseline value is recommended for either commercial or multifamily buildings due to the limited number of data points.	Agreed, This baseline corresponds to the minimum specified by 2009 IECC and ASHRAE 90-1-2007 for WSHPs <17MBTUH cooling and <135 MBTUH heating. Recommend considering raising EER to 12.0 for systems with larger cooling capacities.
Lighting power density for each building area type	0.7	No changes to the baseline values are recommended due to the limited number of data points.	None