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HERS Index Scores as an Alternative Compliance Path for the 2015 IECC

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Final Report

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Background

The analysis presented here is an extension of a previous study on HERS Index Scores as they relate to various version of the International Energy Conservation Code (IECC) by the same author.[1] Since the original report, a coalition of organizations have come together to spearhead an effort to propose and support the incorporation of an Energy Rating Index compliance path in the 2015 IECC, for which the HERS Index Score would be one method of compliance.[2] The numerical designation for this joint IECC proposal is RE 188-13 as modified by public comments 2 and 3.

The ERI scores proposed as compliance criteria by the coalition supporting RE 188-13 as modified by public comments 2 and 3 are as follows:

Climate Zones 1-3:	59
Climate Zones 4-5:	63
Climate Zone 6:	62
Climate Zones 7-8:	60

RE 188-13 as modified would also require that the mandatory measures of the code be met and that the building comply with the minimum envelope values of the 2009 IECC.

This extension of the previous study is designed to examine the impact of advanced, ultra-high efficiency appliances and high efficiency HVAC systems on HERS Index Scores as they relate to reductions in the HERS Index Scores that may be used as "tradeoffs" against best practice envelope efficiencies.

Methodology

As in the previous study[1], one-story, 2000 ft^2, 3-bedroom frame homes and two-story, 2400 ft^2, 3-bedroom frame homes were configured to simulate the IECC *Standard Reference Design*. However, for this study the configuration of the baseline homes was a combination of the 2009 IECC envelope specifications coupled with the 2012 specifications for lighting, envelope air leakage, and duct leakage. Additionally, this study is much more limited, examining results in only three cities representing cooling

[1] Fairey, P., February 21, 2013. "Analysis of HERS Index Scores for Recent Versions of the International Energy Conservation Code (IECC)." FSEC Report No. FSEC-CR-1941-13, Florida Solar Energy Center, Cocoa, FL. (http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1941-13_R01.pdf)
[2] The coalition supporting RE 188-13 comprises the National Resource Defense Council (NRDC), the Institute for Market Transformation (IMT) and the Leading Builders of America (LBA).

dominated, heating dominated and mixed climates (Miami, Fargo and Baltimore, respectively).

As in the previous study, windows were configured such that 35% of the total window area was located on the north and south faces of the home and 15% was located on the east and west faces. This allowed the simulations to examine a *best-case* orientation scenario with the front of the homes facing north and a *worst-case* scenario with the front facing east. The front of the homes also had a 20-foot adjoining garage wall. The foundation for the homes was varied by IECC climate zone with slab-on-grade foundations in the Miami homes, vented crawlspace foundations in Baltimore homes and with unconditioned basement foundations in the Fargo homes.

Tables 1 through 7 and Figures 1 through 5 present the characteristics of the 20 different home configurations analyzed in each climate in the simulation analysis.

Table 1: *Best-Case* Home Characteristics

Component	1-story	2-Story
1st floor area (ft^2)	2,000	1,200
2nd floor area (ft^2)	0	1,200
Total floor area (ft^2)	2,000	2,400
Total volume (ft^3)	18,000	21,000
N-S wall length (ft)	50	40
E-W wall length (ft)	40	30
1st floor wall height (ft)	9	8
Height between floors (ft)	0	1.5
2nd floor wall height (ft)	0	8
Door area ft^2)	40	40
2009 - 2012 IECC SRD windows:		
Window/floor area (%)	15%	15%
Total window area (ft^2)	300	360
N-S window fraction (%)	35%	35%
E-W window fraction (%)	15%	15%

Table 2: 2009 IECC Envelope Insulation Values

LOCATION	IECC CZ	Ceiling R-value	Wall R-value	Found. type	Slab R-value	Floor R-value	Fen U-Factor	Fen SHGC
Miami, FL	1A	30	13	SOG	none	n/a	1.20	0.30
Baltimore, MD	4A	38	13	Crawl	n/a	19	0.35	0.40
Fargo, ND	7A	49	21	UCbsmt	n/a	38	0.35	0.40

Notes for Tables 2 & 3:
Wall R-value: cavity fill
SOG = slab on grade
Crawl = crawlspace
UCbsmt = unconditioned basement

Table 3: HVAC Distribution System Specifications

LOCATION	Duct Location	Duct R-value	Air Handler Location	Distribution System Leakage	Return Leak fraction
Miami, FL	Attic	8	Garage	4 cfm/100ft^2 CFA	60%
Baltimore, MD	Crawl	8	Crawl	4 cfm/100ft^2 CFA	60%
Fargo, ND	UCbsmt	8	UCbsmt	4 cfm/100ft^2 CFA	60%

Table 4: Envelope Leakage & Mechanical Ventilation Specifications

LOCATION	Envelope Leakage	Mechanical Vent Type	Mechanical Vent Rate	Mechanical Vent Power
Miami, FL	5 ach50	None	None	None
Baltimore, MD	3 ach50	Balanced	60 cfm	30 watts
Fargo, ND	3 ach50	Balanced	60 cfm	30 watts

Table 5: Baseline HVAC Equipment

LOCATION	IECC CZ	Heating System		Cooling System		Water Heater	
		Fuel	Eff	Fuel	SEER	Fuel	EF
Miami, FL	1A	elec	7.7	elec	13	elec	0.92
Baltimore, MD	4A	gas	78%	elec	13	Gas	0.59
Fargo, ND	7A	gas	78%	elec	13	Gas	0.59

Table 6: Common HVAC Equipment

LOCATION	IECC CZ	Heating System		Cooling System		Water Heater	
		Fuel	Eff	Fuel	SEER	Fuel	EF
Miami, FL	1A	elec	8.2	elec	14.5	elec	0.92
Baltimore, MD	4A	gas	90%	elec	14.5	Gas	0.59
Fargo, ND	7A	gas	90%	elec	14.5	Gas	0.59

Table 7: ENERGY STAR Most Efficient HVAC Equipment

LOCATION	IECC CZ	Heating System		Cooling System		Water Heater	
		Fuel	Eff	Fuel	SEER	Fuel	EF
Miami, FL	1A	elec	9.6	elec	18	elec	0.92
Baltimore, MD	4A	gas	97%	elec	18	Gas	0.59
Fargo, ND	7A	gas	97%	elec	18	Gas	0.59

Unlike in the original study, simulations for this study were accomplished using the latest version of EnergyGauge USA (v.3.1.02), which is a RESNET-accredited HERS Simulation Tool based on hourly DOE-2 simulations.

Ultra-High Efficiency Appliances

Again unlike the original study, this study focused on the implications of ultra-high efficiency appliances and 100% high efficiency lighting. The appliances selected represent the best available appliance technologies currently available, generally corresponding to the Energy Star Most Efficient criteria where such criteria exist, and result in significant energy use savings compared with the reference standard appliances against which they are compared. In addition, the dishwasher and clothes washer specifications result in substantial hot water use and energy savings of about 10 gallons per day of hot water use and about 15% energy savings. In addition, ceiling fans were also incorporated into the current analysis. The ultra-high efficiency ceiling fans used here have an efficiency of 270 cfm/watt as compared with the reference standard ceiling fan with an efficiency of 70.5 cfm/watt, resulting in significant ceiling fan savings. Except for the ceiling fans, the appliance characteristics used in the current study are shown as the input screens to the EnergyGauge USA software in Figures 1 – 5 below.

Figure 1. Refrigerator Input Screen

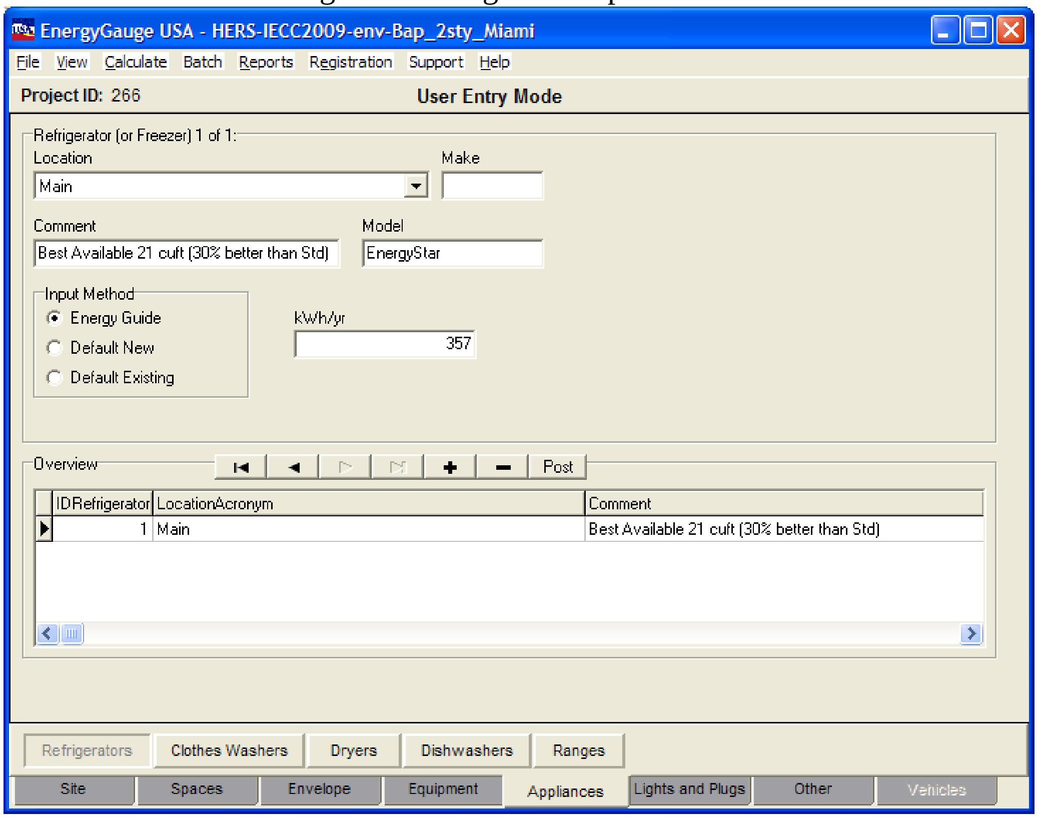


Figure 2. Clothes Washer Input Screen

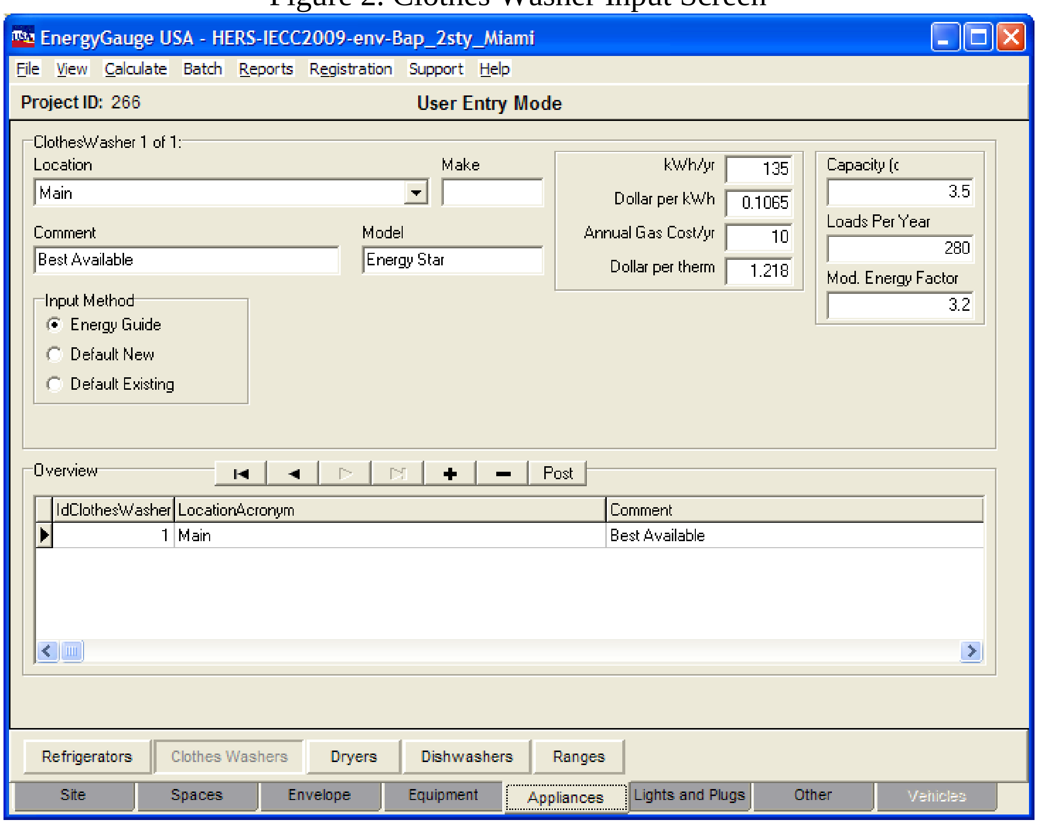


Figure 3. Clothes Dryer Input Screen

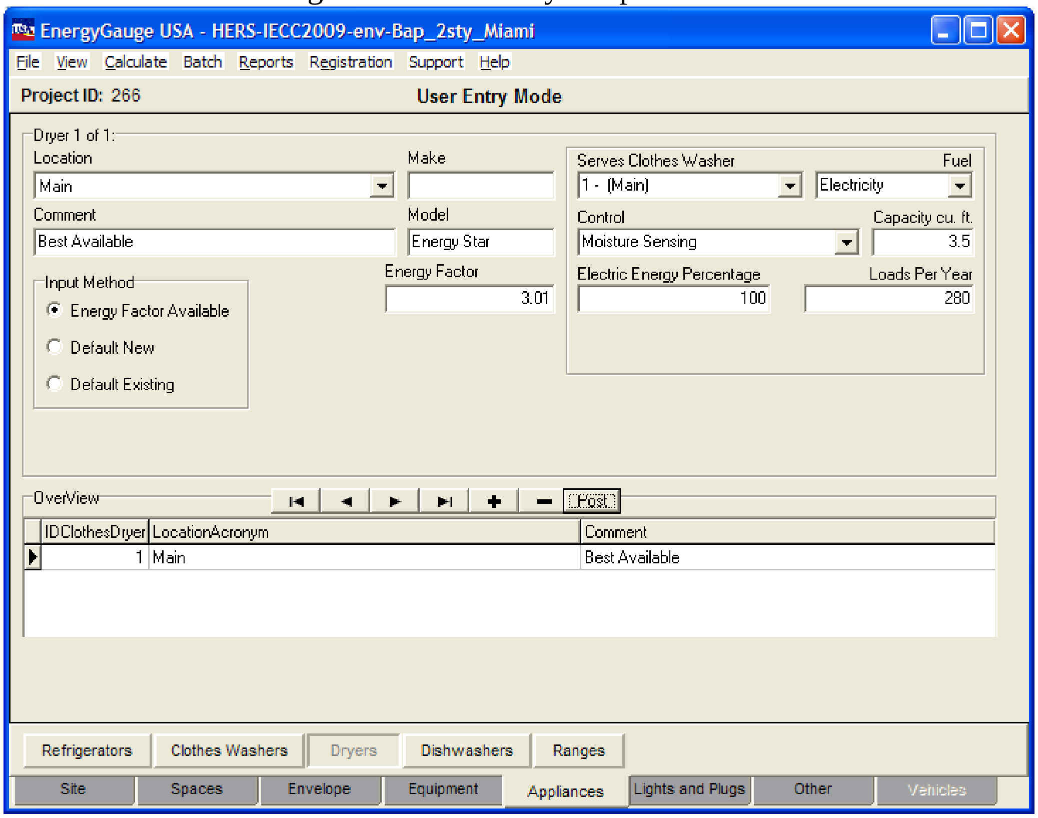


Figure 4. Dishwasher Input Screen

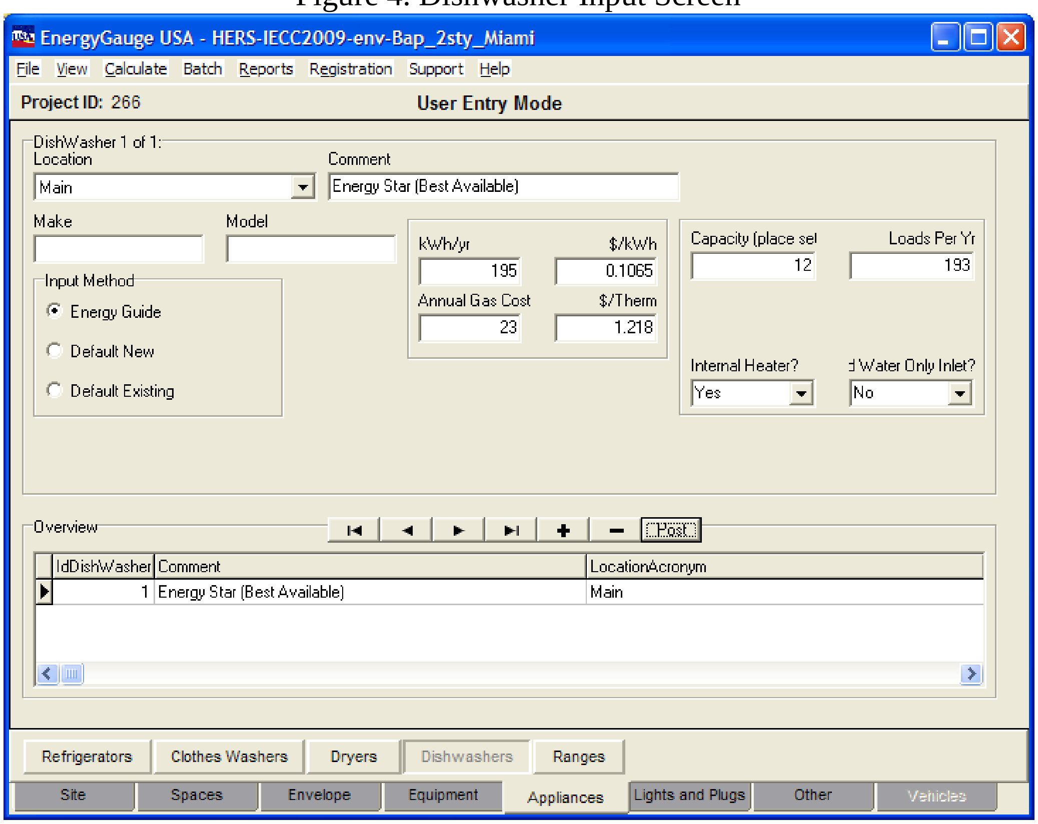
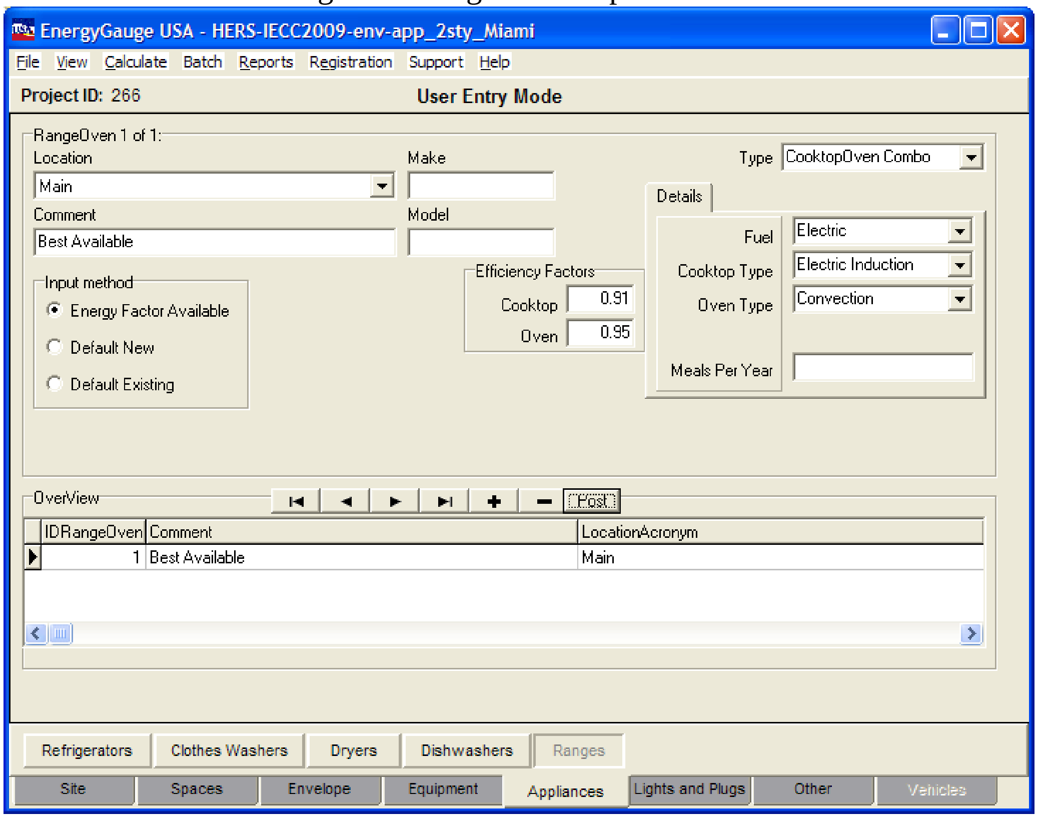


Figure 5. Range/Oven Input Screen



Findings

The energy savings produced by the ultra-high efficiency appliances and the improved lighting were significant, representing 46.2% overall appliance and lighting savings as compared with the baseline home used for the analysis. Table 8 presents the energy savings results for each appliance as well as the total energy savings.

Table 8. Energy savings produced by ultra-high efficiency appliances

End use	**Baseline (MBtu/y)**	**Rated (MBtu/y)**	**% Saved**
Lighting (75% > 100%)	5.17	3.65	29.4%
Refrigerator	2.36	1.22	48.3%
Dishwasher	0.58	0.40	31.0%
Ceiling Fans	2.22	0.58	73.9%
Clothes Washer	0.24	0.12	50.0%
Clothes Dryer	3.31	1.00	69.8%
Range/oven	1.53	1.32	13.7%
Total	**15.41**	**8.29**	**46.2%**

In addition to these savings, there were hot water energy savings of approximately 15% due to the improved hot water efficiency of the dishwasher and clothes washer.

Internal gains in homes are also reduced by these increased appliance and lighting efficiencies. Cooling energy requirements are reduced and heating energy requirements are increased, resulting in a significantly larger impact in the cooling dominated climate of Miami than in the heating dominated climate of Fargo.

HERS Index Scores are impacted commensurate with these appliance energy and hot water savings. Table 9 presents HERS Index score results from the study. The direct impact of the ultra-high efficiency appliances and 100% high efficiency lighting are shown by the difference between the columns labeled ‘Baseline’ and ‘Bap.’ This difference, in terms of the change in average HERS Index Score, is 12 points in Miami, 8 points in Baltimore and 6 points in Fargo, illustrating the climate dependence of improved appliances as they are related to internal gains in homes.

Table 9. HERS Index Score results for all simulations

Miami	**Baseline**	**Bap**	**Bap-Ceq**	**Bap-Beq**	**Bap-Beq-inD**
2sty-BestCase	77	66	60	54	49
2sty-WorstCase	78	67	61	55	51
1sty-BestCase	80	68	62	56	51
1sty-WorstCase	82	69	63	57	52
Mean	**79.3**	**67.5**	**61.5**	**55.5**	**50.8**
Standard Deviation	**2.2**	**1.3**	**1.3**	**1.3**	**1.3**
Baltimore	**Baseline**	**Bap**	**Bap-Ceq**	**Bap-Beq**	**Bap-Beq-inD**
2sty-BestCase	81	74	66	61	55
2sty-WorstCase	83	76	68	63	57
1sty-BestCase	83	75	67	62	58
1sty-WorstCase	85	77	69	64	59
Mean	**83.0**	**75.5**	**67.5**	**62.5**	**57.3**
Standard Deviation	**1.6**	**1.3**	**1.3**	**1.3**	**1.7**
Fargo	**Baseline**	**Bap**	**Bap-Ceq**	**Bap-Beq**	**Bap-Beq-inD**
2sty-BestCase	79	73	64	59	55
2sty-WorstCase	80	74	65	60	56
1sty-BestCase	81	75	65	61	57
1sty-WorstCase	82	76	66	62	57
Mean	**80.5**	**74.5**	**65.0**	**60.5**	**56.3**
Standard Deviation	**1.3**	**1.3**	**0.8**	**1.3**	**1.0**

Key to Column Headings:

Baseline = 2009 envelope plus 2012 ach50, duct leakage and lights (75%)
Bap = Baseline + best available appliances and lights (100%)
Bap-Ceq = Baseline + best avail appliances and lights & common HVAC equip
Bap-Beq = Baseline + best avail appliances and lights & ENERGY STAR most efficient HVAC equip
Bap-Beq-inD = Baseline + best avail appliances and lights & best avail HVAC with leak free, interior ducts

Table 9 illustrates that the 2009 IECC envelope with 2012 envelope and duct leakage and 2012 lighting requirements will not meet the criteria of RE 188-13 by a significant amount. Introducing the best available ultra-high efficiency appliances is also not sufficient to meet the RE 188-13 criteria, nor is the addition of common high efficiency HVAC equipment. Only when the best available HVAC equipment is introduced can these homes comply with the criteria of RE 188-13 as modified and even this is not true in all cases. For example, the 1-story worst case home will not qualify in Baltimore (climate zone 4, where the qualifying criteria is a HERS Index Score of 63 or lower) and the 1-story home in Fargo (climate zone 7, where the qualifying criteria is a HERS Index Score of 60). Only when the air distribution system is moved into the conditioned space and all ducts are leak free, will all homes meet the qualifying criteria in all climates.

Conclusions

Based on the above finding, the following two conclusions may be drawn.

- Homes in cooling dominated climates gain substantially more credit for increased appliance efficiency than homes in heating dominated climates
- It is unlikely that best practice envelope design and construction will be compromised by envelope tradeoffs with either appliance efficiency credits or common HVAC efficiency credits.