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2015 National Green Building Standard Chapter 7 Energy Efficiency Points Analysis

Prepared For

Task Group 5 on Energy Efficiency

May 2015

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DEFINITIONS

ANSI	American National Standards Institute
BA	DOE’s Building America Research Program
EIA	U.S. Energy Information Administration
IECC	International Energy Conservation Code
NGBS	*ICC 700 National Green Building Standard™*
NREL	National Renewable Energy Laboratory
SEF	Solar Energy Factor
RESNET	Residential Energy Services Network
UA	Area weighted overall heat transfer co-efficient in Btu/hr·°F
U-value	Heat transfer coefficient in Btu/hr·°F·ft^2
DHW	Domestic Hot Water
SDHW	Solar Domestic Hot Water
AFUE	Annual Fuel Utilization Efficiency, dimensionless
SEER	Seasonal Energy Efficiency Ratio
HSPF	Heating Season Performance Factor
COP	Coefficient of Performance (Heating)
EER	Energy Efficiency Ratio (Cooling)

BACKGROUND

The 2015 version of the *ICC 700 National Green Building Standard™* (NGBS) will be the third iteration of this national residential standard. It was originally developed by a consensus committee and approved by the American National Standards Institute (ANSI) in January 2009, making it the first point-based rating system for green residential construction, remodeling, and land development to be approved by ANSI. As an ANSI-approved standard, the document is subject to periodic updates as a way to ensure that advances in building codes, technology, and other developments can be considered for incorporation. The NGBS was updated in 2012 and again approved by ANSI in January 2013.

The NGBS (2008, 2012) was developed by a balanced consensus committee of general interest, producers, and users. Periodic maintenance of an ANSI standard by review of the entire document and action to revise or reaffirm it on a schedule not to exceed five years is required by ANSI. In compliance with this periodic maintenance requirement, a statement of notification to review and/or revise the NGBS was issued in February 2014. In keeping with the standards development procedures, a consensus committee has once again been formed to develop the 2015 NGBS.

The NGBS is a system of rating the sustainability of the siting, construction practices and products, and expected performance of a residential building. Point thresholds determine the project's compliance with the criteria that support progressively higher rating levels: Bronze, Silver, Gold and Emerald. Practices defined in the areas of site development, resource efficiency, energy efficiency, water efficiency, indoor environmental quality, and operation, maintenance, and education earn points toward an overall green rating level. The scope of standard includes both single-family and multifamily buildings, as well as existing residential buildings.

INTRODUCTION

Chapter 7 of the NGBS-2012 addresses the energy efficiency (EE) of residential buildings. As with previous versions of the NGBS, to be useful to a broad spectrum of builders, the NGBS-2012 allows a choice between a performance and a prescriptive approach to achieve the Energy Efficiency Chapter 7 point thresholds for the Bronze, Silver, and Gold levels. The highest level rating (Emerald), requires use of the performance compliance approach.

As part of the periodic maintenance of the ICC-700 National Green Building Standard, the EE portion of the NGBS (Chapter 7 Energy Efficiency) is being updated and is the focus of the analysis outlined in this report. Unique to the energy efficiency chapter of the NGBS, both performance (qualitative simulation-based estimates) and prescriptive (specific technology selections) methodologies are employed to evaluate achievement of various green performance levels (Bronze, Silver, Gold, Emerald). The purpose of this analysis is to generally align both methodologies such that either approach will provide a generally similar level (though not exact) of energy savings.

There are two primary considerations for the energy efficiency chapter update process. The first is the baseline for energy performance against which savings is determined and the second is the methodology to determine energy savings of individual and combinations of practices. Any updates and revision to the NGBS energy chapter is proposed to continue the methodology first established for the

2012 NGBS using a whole-house energy savings analysis. Employing this approach, energy savings is estimated relative to a defined starting point. The degree to which energy savings exceeds the defined starting point is related to the green level attained in NGBS Chapter 7, Energy Efficiency.

NGBS-2012 Background

Chapter 7 of the 2012 version of the NGBS (2008, 2012) contains five sections titled:

701 – Minimum Energy Efficiency Requirements
702 – Performance Path
703 – Prescriptive Path
704 – Additional Practices
705 – Innovative Practices

Overall, Section 701 contains Mandatory practices required of every home seeking certification under the NGBS. These practices are consistent with minimum energy efficiency requirements of the 2009 IECC and garner no points toward certification. Section 702 outlines the methodology to score points based on a software analysis of estimated energy savings when compared to a baseline (i.e., 2009 IECC compliant house with federal minimum efficiency equipment). Section 703 identifies specific practices that can be selected and added together. Sections 702 Performance Path and 703 Prescriptive Path are mutually exclusive. Either path may obtain additional points from Sections 704 and 705, without limit.

When developing the point levels for Section 703, a new analysis methodology was developed for the NGBS-2012 with the goal of increasing the consistency between the Prescriptive Path and the Performance Path. This consistency would ideally result in a similar energy savings estimate when either the Prescriptive or Performance Paths were selected. One significant change approved for the NGBS-2012 was the placement of a number of 704 and 705 practices into the Prescriptive (703) Path so to better reflect a whole-house analysis and thereby aligning the chapter's rating system for both compliance path approaches more closely with the effective whole-house energy savings results.

The NGBS-2012 also redefined the levels of merit within the NGBS as 15%, 30%, 40%, and 50% better "whole-house" energy performance than the 2009 IECC (NGBS-2008 levels were 15-60% over the 2006 IECC).

Proposed Changes for the NGBS-2015

A consensus committee was convened in 2014 to update the 2012 version of the NGBS. As part of this process, task groups were developed to address specific topics and make recommendations to the consensus committee. Chapter 7 review was assigned to Task Group 5. A primary goal of Task Group 5 was to address recommended changes to the NGBS-2012. Because a change to the baseline energy code (from 2009 IECC to 2015 IECC) was recommended by the consensus committee and because of a number of other recommended changes to Chapter 7, a reassessment of the point assignments for the Prescriptive path (Section 703) was requested by the Consensus Committee.

Now in the development stage for the NGBS-2015, Task Group 5 is responding to proposed changes to the Energy Efficiency chapter of the NGBS-2012. Though currently awaiting final approval from the consensus committee, specific proposed changes of interest include:

- Use of and compliance with, the 2015 IECC as the baseline energy performance metric to achieve the lowest (Bronze) level of certification;
- Transfer of specific Prescriptive (Section 703) provisions that previously were awarded points to the Minimum Energy Efficiency Requirements (Mandatory, Section 701) based on changes in the 2015 IECC from the 2009 IECC;
- Inclusion of a new Section 704 HERS Index Target Path;
- Changes to the practices and points in Sections 705 (formerly 704) and 706 (formerly 705); and
- Recommended revised point thresholds for the Prescriptive Path as 30, 45, 60, and 70 to correspond to Bronze, Silver, Gold, and Emerald rating levels.

Working in parallel with the recommendations proposed by Task Group 5, this report details the analysis performed to review/revise the Prescriptive Path (Section 703) of Chapter 7 Energy Efficiency point structure that will support the stated energy savings thresholds that will be ultimately recommended to the Consensus Committee for approval. The analysis performed to revise the 703 point structure is generally consistent with the analysis performed for the NGBS-2012 and will be outlined in the following report sections. The analysis does not address Sections 705 and 706 that contain practices that cannot be directly modeled using commercially available software.

ANALYSIS METHODOLOGY

Points awarded in the Energy Efficiency chapter of the NGBS are intended to reflect energy savings. Higher energy savings results in a higher green level of merit. Beginning with the 2008 National Green Building Standard, the general relationship between points and energy savings is intended to be linear – 1 point reflects a one-half percent in energy savings and is defined in terms of energy costs. Starting with the NGBS-2012, energy savings is based on the whole-house energy use.

The Prescriptive path (Section 703) outlines various energy efficiency features that can be selected individually to accrue points. The more features selected, the higher number of points and therefore energy savings. Energy simulations and analysis are necessary to determine and assign point levels for specific energy features and for each feature in a climate zone. Furthermore, combinations of features generally result in overall lower savings than the sum of individual features evaluated independently, and therefore require some calibration so as to avoid over estimation of savings.

Energy simulation software that provide whole-house energy estimates are based on a house configuration and specific envelope characteristics. For this analysis, a standard house design is developed and used in all climate zones but with variations in the foundation to reflect geographic differences. Also required for simulations is a specific location (i.e. city) on which average weather data is based and drives heating, cooling, and to some extent, water heating and lighting loads.

Given that the NGBS uses energy cost as the comparison metric for energy savings, utility rates for natural gas and electricity are needed and used to convert site energy use estimates from the software output.

House characteristics, representative climate locations, and energy costs serve as the fundamental standard input for the software and the basis for variations in energy features. The standard house layout is then tuned to each climate zone using energy features outlined in the IECC 2015 and identified as the "Baseline" house design. The baseline house and resultant energy estimates (baseline energy use) provide the basis for comparison of energy estimates that result from enhanced energy features.

The analysis process then uses this baseline house and energy estimate for each representative city as the starting point. Next, a Prescriptive practice in section 703 is simulated and the resultant energy savings is calculated as a percentage of the baseline cost. Most, but not all, practices in the prescriptive section can be modelled in software. If modelling capabilities are lacking, estimates of savings are made using various methods such as comparisons with similar technologies or other resources that provide energy savings estimates.

Following simulations of individual energy features and development of cost savings percentages in each of the representative cities, a set of features is selected to represent a higher performing home design. For this purpose, a set of features that result in approximately 30% savings over the baseline house is selected and includes envelope, HVAC, water heating, lighting, and appliance efficiency enhancements that reflect the most common approaches to increasing the efficiency of the home. The energy cost savings from this set of combined energy efficiency features is then compared to the sum of the individual savings features. If differences exist, the individual savings estimates are then calibrated by the results from the combination of features. This calibration factor is then applied to each of the prescriptive provisions.

Once each of the prescriptive practices that have been simulated is calibrated, the resultant cost savings percentages are doubled to develop the point structure for the prescriptive practices. Finally, to obtain points for a given prescriptive practice in a climate zone, multiple simulations within any one climate zone are averaged. This applies to multiple cities in a climate zone and simulations of dry or moist climates within the same climate zone.

Two software packages are used for this analysis. BEopt[1] software (version 2.3.0.2) is used to develop energy savings for individual prescriptive practices. BEopt uses a simulation engine employing average hourly weather data and has many built-in energy efficiency technologies and performance characteristics based either on manufacturer data or current research. REMrate[2] software (version 14.6.1) is used to develop whole-house energy savings results for combinations of features. This was selected since many verifiers and raters use the REMrate software for energy analysis and have built-in features to compare the energy estimates for the house design with that of a code-minimum house or to develop HERS Indices. REMrate will provide the comparison with the 2015 IECC code minimum house as proposed as a requirement in the proposed Energy Efficiency chapter of the NGBS (similar to the 2009 IECC requirement in the NGBS-2012).

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[1] Developed and maintained through the National Renewable Energy Laboratory (NREL), refer to http://beopt.nrel.gov/ for a description of the software and its capabilities.

[2] REM/Rate™ and REM/Design™ are trademarks of NORESCO, LLC. NORESCO is a part of UTC Building & Industrial Systems, a unit of United Technologies Corp, refer to www.remrate.com/ for a complete description.

This analysis methodology generally allows for the comparison between the Prescriptive and Performance paths in the NGBS, Energy Efficiency chapter. Note that any further points obtained from sections for Additional and Innovative practices (705 and 706 as renumbered in the proposed NGBS) may not be adequately modeled in software but are still counted as energy savings. These Best Practices or other qualitative efficiency enhancements may practically result in reduced energy consumption but are not easily modeled given current software capabilities.

The analysis methodology provided herein is consistent with the analysis performed during the development of the NGBS-2012[3] and is outlined in the following sections of this report.

Baseline Energy Performance

Early in the 2015 NGBS maintenance/update process the consensus committee convened to review proposed changes to the 2012 NGBS. One such change was to base the energy efficiency Chapter 7 of the NGBS on the 2015 International Energy Conservation Code[4] (2015 IECC). Whereas the 2012 NGBS was based on the 2009 IECC, this proposed change for the 2015 NGBS leapfrogs the 2012 IECC and represents a significant increase in the minimum requirements for NGBS certification including:

- Higher levels of envelope insulation;
- Lower infiltration rates and required testing;
- Higher performing windows;
- Larger percentage of high efficacy lighting; and
- Duct air leakage requirements and testing, among other changes.

Use of the 2015 IECC as the baseline energy performance metric sets a firm minimum for estimates of energy consumption in order to reach any green level in the Energy Efficiency chapter for NGBS certification.

ANALYSIS OF ENERGY EFFICIENCY

Baseline Modeling Parameters

Quantization of energy savings requires a defined baseline which includes the house characteristics, climate zone, energy costs, building energy features, occupancy assumptions, and others. Once the baseline is defined, software is used to estimate energy use. Energy savings is then quantified when various energy features are modified in the baseline models. In this analysis of energy efficiency features for the proposed NGBS-2015, the baseline is developed using a combination of resources.

Standard House Design and Representative Cities: Consistent with the previous NGBS-2012 analysis, a standard house design was developed from statistics from annual builder surveys compiled by the Home Innovation Research Labs. The standard house design for the NGBS-2015 is slightly larger than the previous design based on current data, with similar ratios for wall and roof areas. This standard house

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[3] Refer to the Home Innovation Research Labs report developed for the Building America Program dated June 2012 at http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/ngbs_analysis.pdf .

[4] 2015 International Energy Conservation Code®, INTERNATIONAL CODE COUNCIL, INC., Date of First Publication: May 30, 2014.

design is modeled on various foundations, again selected from statistical data by region and consistent with the previous analysis. Climate zones and cities within the zones used in models were selected from various resources[5,6,7] and are similar to the previous analysis but with the addition of two more cities. The climate zones extend from 1 through 8 (covering the continental United States) and the selected locations include moist and dry climates in select zones, as appropriate. Fifteen cities were selected to represent the eight climate zones in the country. Table 1 list the house design details and Table 2 shows the location information and foundation types used in the energy simulations.

Table 1. Characteristics of Reference Houses

House Characteristic	NGBS-2012 Dimension	NGBS-2015 Dimension
Above-Grade Conditioned Area, sq.ft.	2,401	2,500
First Floor Area, sq.ft.	1,801	1,875
Second Floor Area, sq.ft.	600	625
Slab/Basement Area, sq.ft.	1,801	1,875
Slab/Basement/Crawl Perimeter, sq.ft.	196	200
First Floor Height, ft.	9.0	9.0
Second Floor Height, ft.	8.5	8.0
Basement Height, ft.	8.0	8.0
Basement/Crawl Wall Above Grade, sq.ft.	392	200
Window Area (Slab Foundation), sq.ft.	360	375
Window Area (Basement Foundation), sq.ft.	420	429
Above-Grade Wall Area, sq.ft.	2,597	2,700
Basement Wall Area, sq.ft.	1,568	1,600
Number of Bedrooms	3	3
Number of Bathrooms	2.5	2.5
Roof Overhang, ft.	1	1

Table 2. Locations, Degree-Days, and Foundations of Reference Houses

Climate Zone	Location	Climate	Heating DD 65°F Base	Cooling DD 65°F Base	Foundation		
					Slab	Crawl space	Base-ment
1A	Miami, Florida	Hot, Humid	149	4,293	X		
2A	Houston, Texas	Hot, Humid	1,438	2,974	X		
2B	Phoenix, Arizona	Hot, Dry	996	4,591	X		
3A	Atlanta, Georgia	Hot, Humid	2,773	1,810	X	X	
3A	Dallas, Texas	Hot, Humid	2,332	2,678	X	X	
3B	Las Vegas, Nevada	Hot, Dry	2,301	3,186	X		
4A	Baltimore, Maryland	Mixed, Humid	4,631	1,237	X		X
4A	Kansas City MO	Mixed, Humid	5,435	1,316	X		X
4C	Seattle, Washington	Marine	4,641	128		X	
5A	Chicago, Illinois	Cold, Humid	6,398	830			X

[5] http://www1.eere.energy.gov/buildings/challenge/technical_resources.html

[6] Technical Support Document: 50% Energy Savings for Small Office Buildings, Liu, B., et al. PNNL-19341, April 2010

[7] www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1981-14.pdf

Climate Zone	Location	Climate	Heating DD 65°F Base	Cooling DD 65°F Base	Foundation		
					Slab	Crawl space	Base-ment
5B	Denver, Colorado	Cold, Dry	5,654	924			X
6A	Minneapolis, Minnesota	Cold, Humid	7,782	731			X
6B	Helena, Montana	Cold, Dry	7,587	319			X
7A	Fargo, North Dakota	Very Cold	9,211	490			X
8B	Fairbanks, Alaska	Extreme Cold	13,072	30	X		

A graphical representation of the house design in the modelling software is shown in Figure 1.

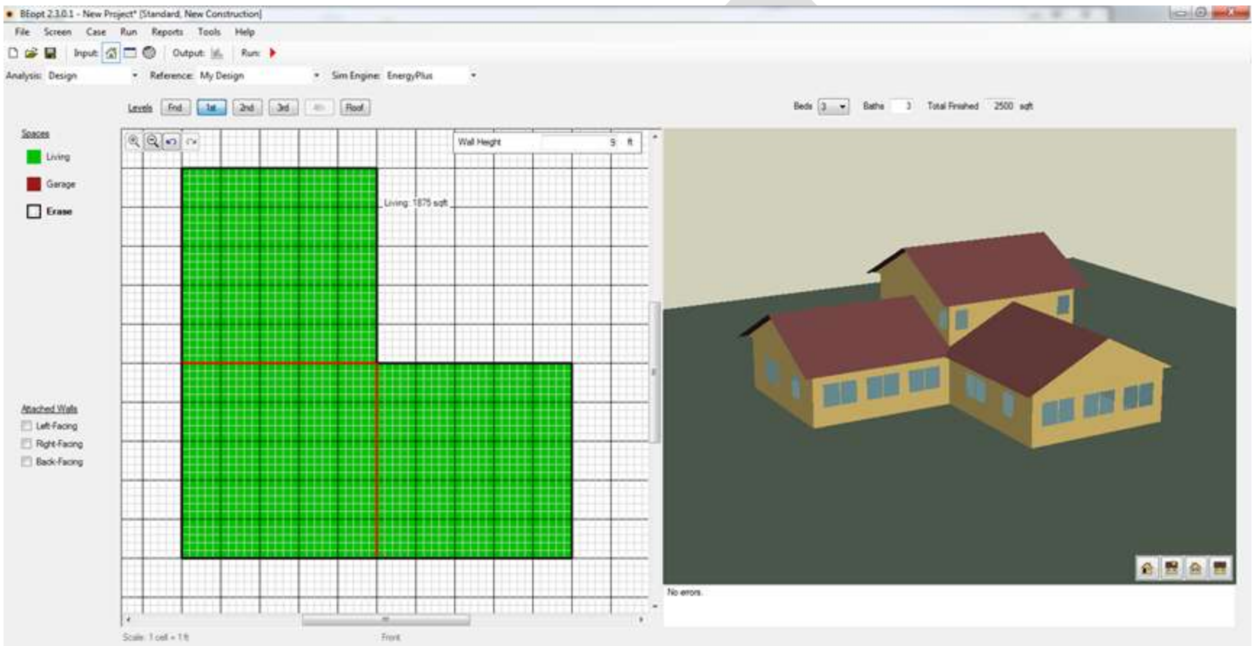

Figure 1. Typical House Design Used in the Analysis in BEopt Software

Building Envelope Baseline Energy Features: As proposed for the NGBS-2015 and used in this analysis, the baseline energy code for the Energy Efficiency chapter is the 2015 IECC. Envelope insulation levels, window U-values, maximum air infiltration rates, use of high efficiency lighting, and other energy feature requirements are outlined in the IECC. These house features, in conjunction with federal minimum efficiency equipment, are used in software simulations to estimate baseline energy use.

The envelope features were developed for the house design in each of the modeled climates. Table R402.1.4 Equivalent U-Factors[8] of the 2015 IECC (Figure 2) shows the U-values for all envelope surfaces, including windows.

[8] U-factors or U-values are in Btu/hr·°F·ft². U-values applied over specific envelope surface areas result in the UA of that area (such as a ceiling or wall) and are in Btu/hr·°F.

TABLE R402.1.4
EQUIVALENT U-FACTORS[a]

CLIMATE ZONE	FENESTRATION U-FACTOR	SKYLIGHT U-FACTOR	CEILING U-FACTOR	FRAME WALL U-FACTOR	MASS WALL U-FACTOR[b]	FLOOR U-FACTOR	BASEMENT WALL U-FACTOR	CRAWL SPACE WALL U-FACTOR
1	0.50	0.75	0.035	0.084	0.197	0.064	0.360	0.477
2	0.40	0.65	0.030	0.084	0.165	0.064	0.360	0.477
3	0.35	0.55	0.030	0.060	0.098	0.047	0.091[c]	0.136
4 except Marine	0.35	0.55	0.026	0.060	0.098	0.047	0.059	0.065
5 and Marine 4	0.32	0.55	0.026	0.060	0.082	0.033	0.050	0.055
6	0.32	0.55	0.026	0.045	0.060	0.033	0.050	0.055
7 and 8	0.32	0.55	0.026	0.045	0.057	0.028	0.050	0.055

a. Nonfenestration *U*-factors shall be obtained from measurement, calculation or an approved source.
b. When more than half the insulation is on the interior, the mass wall U-factors shall be a maximum of 0.17 in Climate Zone 1, 0.14 in Climate Zone 2, 0.12 in Climate Zone 3, 0.087 in Climate Zone 4 except Marine, 0.065 in Climate Zone 5 and Marine 4, and 0.057 in Climate Zones 6 through 8.
c. Basement wall *U*-factor of 0.360 in warm-humid locations as defined by Figure R301.1 and Table R301.1.

Figure 2. 2015 IECC U-Factor Table

The UA for the baseline house in the respective climate zones and foundation types matches the 2015 IECC reported by REM/Rate to within about 1% (Table 3). Increases in insulation or lower window U-values will result in lower UA values for specific envelope features and can be credited for points in the prescriptive path of the NGBS.

Table 3. Comparison of UA values of House Design to IECC maximums

Reference City	Foundation	UA-Baseline House[A]	UA-2015 IECC Code[B]
Miami, Florida	Slab	528.5	538.2
Houston, Texas	Slab	482.0	487.3
Phoenix, Arizona	Slab	482.0	487.3
Atlanta, Georgia	Slab	409.5	411.7
Atlanta, Georgia	Crawl	433.9	438.8
Dallas, Texas	Slab	409.5	411.7
Dallas, Texas	Crawl	433.9	438.8
Las Vegas, Nevada	Slab	409.5	411.7
Baltimore, Maryland	Slab	343.7	346.8
Baltimore, Maryland	Basement	447.0	453.2
Kansas City MO	Slab	343.7	346.8
Kansas City MO	Basement	447.0	453.2
Seattle, Washington	Crawl	384.1	392.6
Chicago, Illinois	Basement	420.3	424.7
Denver, Colorado	Basement	420.3	424.7
Minneapolis, Minnesota	Basement	384.8	388.2
Helena, Montana	Basement	384.8	388.2
Fargo, North Dakota	Basement	384.8	388.2
Fairbanks, Alaska	Slab	296.1	300.1

[A] As reported by REMrate software for the Baseline house
[B] As reported by REMrate software for the 2015IECC code house (cannot be modified by the user)
UA in Btu/hr·°F·ft^2

Based on the proposed mandatory requirements in Section 703.1.1 (NGBS-2015 Draft Standard), the home design must comply with the insulation (or maximum UA) requirements of the 2015 IECC.

Equipment Baseline Efficiency: In order to obtain the whole-house baseline energy use, minimum equipment efficiencies must be set for space heating and cooling and for domestic water heating (DHW). This aspect of the modelling is of particular importance since minimum equipment efficiency standards have already been updated through the DOE rulemaking process and are being phased in over a time period when the NGBS-2015 will be finalized. Given the proximity of the revised standards, these were used with some modification in the simulations as the baseline equipment efficiency. The revised minimum equipment efficiencies are now tuned more to the climate (Figure 3)[9], however they remain similar in most cases as shown in for electric heating and cooling.

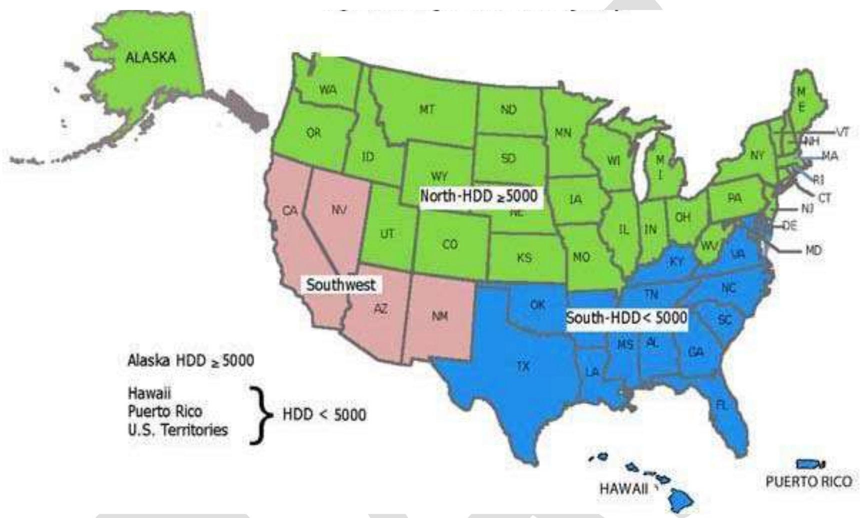

Figure 3. Graphic of Equipment Efficiency Being Phased in Starting in 2015

Minimum furnace equipment efficiency was originally updated along with the electric space conditioning; however, the DOE rulemaking process has been restarted. The current minimum efficiency of 80% for furnaces remains in effect until further updates have been agreed and approved.

For the purposes of this analysis and to maintain consistency in the NGBS, a minimum air conditioner equipment efficiency of 14 SEER, a minimum heat pump efficiency of 14 SEER/8.2 HSPF, and a minimum furnace efficiency of 80% was used in all simulation baseline estimates.

Table 4. Electric Heating and Cooling Minimum Equipment Efficiency

System Type	National Standard	Southeastern Region Standard	Southwestern Region Standard
Split A/C	13 SEER	14 SEER	14 SEER
<45,000 Btu/h			12.2 EER
≥45,000 Btu/h			11.7 EER
Split HP	14 SEER /8.2 HSPF	14 SEER /8.2 HSPF	14 SEER /8.2 HSPF
Package A/C	14 SEER	14 SEER	14 SEER/11.0 EER
Package HP	14 SEER/8.0 HSPF	14 SEER/8.0 HSPF	14 SEER/8.0 HSPF

[9] Graphic extracted from www.appliance-standards.org/sites/default/files/1009hvac_fact.pdf.

Ventilation: All models, baseline and parametric, are simulated using ventilation rates consistent with ASHRAE 62.2-2010. Ventilation is assumed to be exhaust only and rates are applied as continuous.

Appliance and Miscellaneous End Uses: Through the development process for both the Building America Benchmark[10] and the RESNET National Home Energy Rating Standard[11], provide baseline estimates of energy use for appliances and miscellaneous end uses. These estimates were modified where the IECC code requirements take precedence, for example where lighting energy is required to be 75% high efficacy. (This lighting requirement changes the RESNET default of 2680 kWh per year to 1518 kWh per year using REMrate software estimates.)

Table 5. Comparison of Energy Estimates for Lighting, Appliance, and Miscellaneous End Uses

Electric End Use kWh/year	RESNET Standard	Building America Benchmark	REMrate Baseline Estimate	BEopt Baseline Estimate
Interior lighting	2,455	1,351	1,412	
Exterior lighting	225	363	98	
Interior Plug Lighting		338		
Garage lighting				
All Lighting	2,680	2,052	1,518	1,682
Refrigerator	637	434	550	
Freezer				
Dishwasher	171	175	139	
Electric Oven/Range	448	499	448	
Clothes Washer	68	78	69	
Electric Clothes Dryer	971	1,076	980	
All Large Appliances	2,295	2,262	2,185	2,210
Mechanical Vent Fan	217	169	145	170
Ceiling Fan				
Plugs/Misc.	2,895	2,523	2,895	2,342
Total All Uses	**8,087**	**7,006**	**6,743**	**6,404**

Estimates for the Baseline houses modeled in this analysis generally compare well, within about 5%, for the total lighting, appliance, and miscellaneous energy use although differences may exist within a category given the unique modeling features of the software package. In this analysis it was deemed preferable to use built-in models for appliances and miscellaneous uses since these will be used in practice for energy estimates to determine levels of merit for the NGBS.

Energy Costs: The cost for electricity and natural gas are taken from Energy Information Administration (EIA) data and is based on the most recent costs available to the end of 2014 for electricity costs[12] and

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[10] Refer to http://energy.gov/eere/buildings/house-simulation-protocols-report for information on the BA simulation protocols and tools used for house design analysis and specifically Section 2.1.7 Option 1 for lighting energy use and Section2.1.8 for appliances and miscellaneous end uses.

[11] See www.resnet.us/professional/standards/mortgage for all relevant documentation for energy simulation procedures and guidelines and specifically, Table 303.4.1.7.1(1) Lighting, Appliance and Miscellaneous Electric Loads (kWh/yr) in electric HERS Reference Homes of the Mortgage Industry National HERS Standard, January 1, 2013.

[12] For electricity prices, the most recent monthly costs are used. See http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a.

for the 2013 annual period for natural gas[13]. The average costs for the US were used in this analysis. This is a change from the previous analysis where specific data from simulation locations was used. In the previous analysis for the 2012 NGBS, a sensitivity analysis showed little difference if national average rates were used rather than local rates and is confirmed when individual state rates are compared to average U.S. rates as shown in Figure 4 using current EIA data.

Related to energy costs is the selection of fuel used in the homes. The previous analysis used for the 2012 NGBS ran simulations for both gas and electric homes. This analysis relies on natural gas for heating, water heating, and cooking (except for the climate zone 1 which uses only electricity) primarily for all simulation runs. However, where technologies are being evaluated for savings that are electric, an electric baseline is used, for example, with heating systems. The selection of fuels for any one home with access to both gas and electric supplies is somewhat arbitrary, even for areas where both fuel sources are readily available. The analysis used here will minimize any large swings in cost savings between gas/electric and all electric homes. Large differences in costs are graphically shown in Figure 5.

Software simulations: As described above, two software packages were used to estimate energy use. A comparison to evaluate the differences in estimates was developed for both gas/electric and all electric homes. As expected, the results for any one location vary for the software the packages since the simulation engines are quite different, however, the trends in energy cost estimates parallel each other with REMrate estimates consistently exceeding energy cost estimates in BEopt (see Figure 6).

[13] For natural gas prices, the annual US costs for 2013 are used. See http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_a.htm.

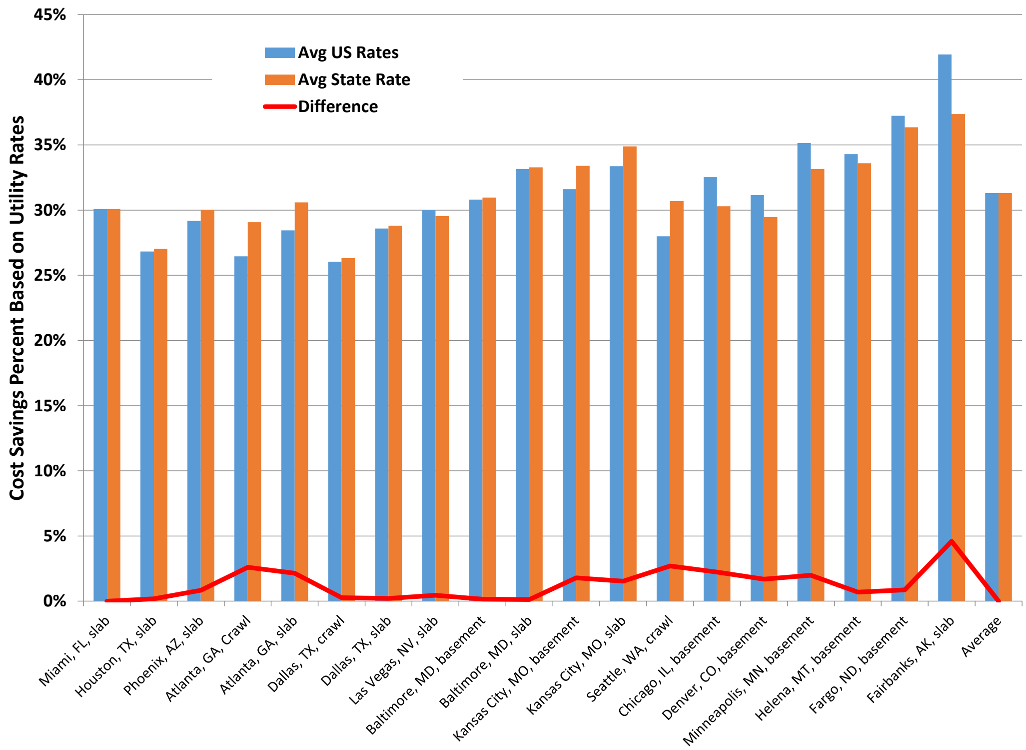


Figure 4. Comparison of cost energy savings for ~30% savings home using average utility rates

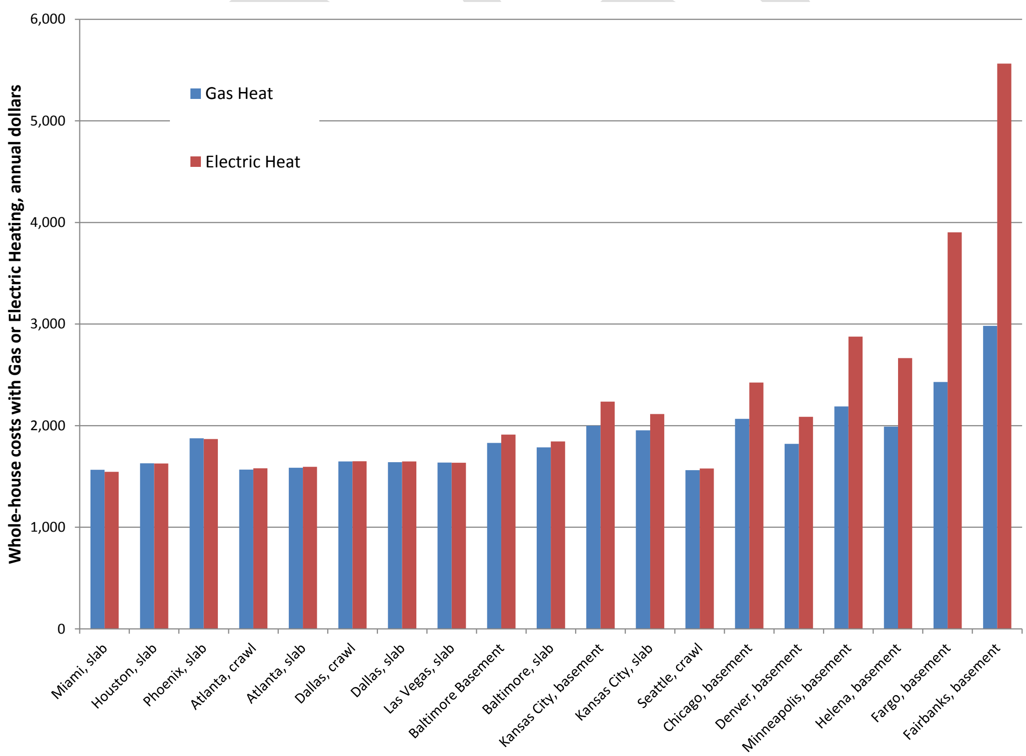
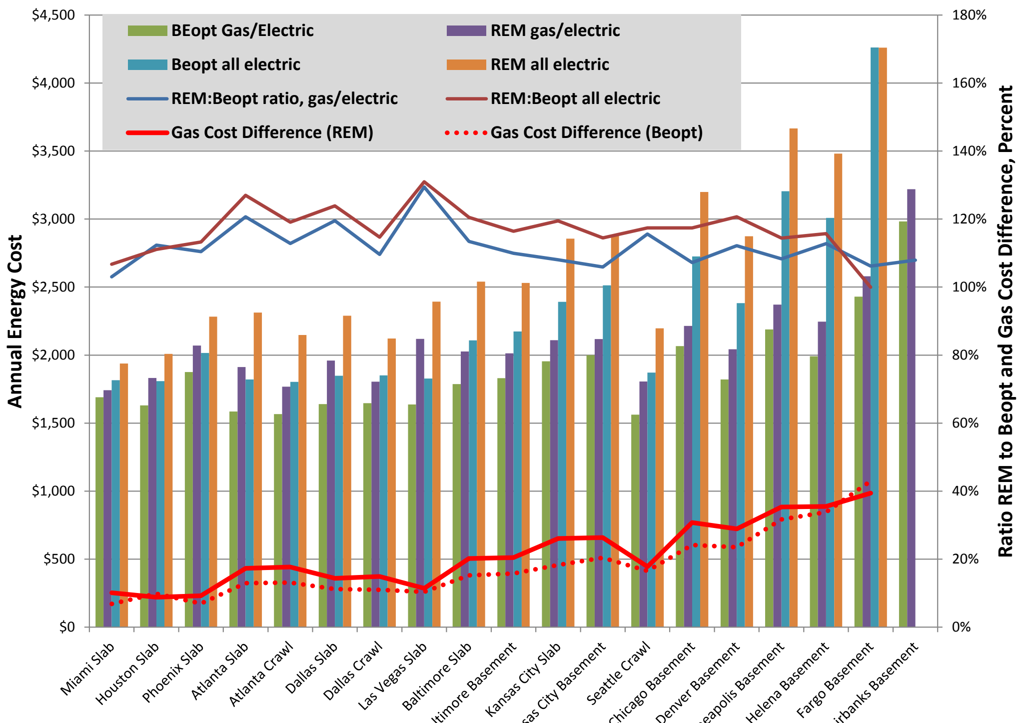


Figure 5. Whole-House Costs with Either Gas or Electric Heating, Annual Dollars



Note: CZ8 - gas/electric only

Figure 6. Energy Cost Comparison between Software Packages

COST SAVINGS FOR PRESCRIPTIVE PRACTICES – MODELING ANALYSIS

The purpose of this analysis is to evaluate energy cost savings for individual prescriptive provisions for Chapter 7 Prescriptive practices (Section 703) of the proposed NGBS-2015. Where modelling software has the capability of simulating a technology, these estimates were used. Where modelling was not feasible, for example with gas engine heat pumps, either previous estimates from the NGBS-2012 were used or new estimates were made based on efficiency improvements of similar technologies. In some cases, simulations were made for sample climate zones to determine if the savings warranted further analysis or if the savings was consistent with previous savings estimates. Prescriptive practices and baseline performance factors to develop energy savings estimates and any applicable performance options are outlined in Table 6.

Table 6. Prescriptive Practice and Modeling Procedure

NGBS-2015 Section	Proposed NGBS-2015 Practice	Baseline Reference	Performance Options
703.2.1	0 to < 5% UA improvement	2015 IECC	Baseline
	5% to < 10% UA improvement		per location Use REMrate or ResCheck for levels
	10% to < 15% UA improvement		
	15% to < 20% UA improvement		
	20% to < 25% UA improvement		
	25% to < 30% UA improvement		
	30% to < 35% UA improvement		
703.2.2	Insulation installation quality		Move to Mandatory
703.2.3	Mass walls (< 6")	no mass	Simulations in select climates
	Mass walls (≥ 6")	no mass	
703.2.4	Radiant barrier	no RB	
703.2.5	Envelope leakage, ACH50	5 (Base CZ 1 & 2)	
		4	CZ 1 & 2
		3 (Base CZ 3 - 8)	
		2	All climate zones
		1	
703.2.6.2.1(a)	Fenestration level 1	2015 IECC Table 402.1.2	NGBS Tables for climate zones
703.2.6.2.1(b)	Fenestration level 2		
703.2.6.2.1(c)	Fenestration level 3		
703.3.1	Combo heating system		
703.3.2	Gas & Oil Furnace efficiency	80%	≥ 85
			≥ 90
			≥ 92
			≥ 94
			≥ 96
			≥ 98
	Boiler efficiency	82%	≥ 85
			≥ 90
			≥ 92
			≥ 94
			≥ 96
703.3.3	Heat Pump Heating	8.2 HSPF	8.5 HSPF
			9.0 HSPF
			9.5 HSPF
			10 HSPF
	Gas Engine Heat Pump Heating		> 1.3 COP at 47F
703.3.4	Electric Air Conditioner and Heat Pump Cooling	14 SEER Air Source Heat Pump	≥ 15 SEER
			≥ 17 SEER
			≥ 19 SEER
			≥ 21 SEER
	Gas Engine Heat Pump Cooling		> 1.2 COP at 95F
703.3.5	Water Source and cooled A/C	14 SEER Air Source Heat Pump	≥ 4 COP, 15 EER

NGBS-2015 Section	Proposed NGBS-2015 Practice	Baseline Reference	Performance Options
703.3.6	Ground Source Heat Pump	14 SEER Air Source Heat Pump	14.1 EER, 3.3 COP
			15 EER, 3.5 COP
			16.2 EER, 3.6 COP
			24 EER, 4.3 COP
			28 EER, 4.8 COP
703.3.7	E* ceiling fans	Standard	
703.3.8	whole house ventilation fan	none	
703.3.9	Submeter in multiunit	none	
703.4.1	Ductless heating system	Standard duct install and location based on foundation	
703.4.2	Ductless cooling system		
703.4.3	Duct installation (interior+)		
703.4.4	Duct leakage 6% out	4 cfm/100sf	< 4 cfm/100sf
703.5.1	Gas Water Heating (Use 40 Gallon for NGBS design)	0.61 Energy Factor (40 gallon)	0.67 to < 0.80 EF
			≥ 0.80
	Large storage or Instantaneous		≥ 0.90
			≥ 0.95
	Electric Resistance Water Heating	0.95 (50 gallon)	> 0.95
	Electric Instantaneous Water Heating		≥ 0.97
	Heat Pump Water Heater	.61 EF gas .92 Electric	1.5 to < 2.0
			2.0 to < 2.2
			≥ 2.2
703.5.2	Desuperheater		
703.5.3	Drainwater heat recovery		
703.5.4	Indirect water heater		
703.5.5	Solar Water Heating Gas or Electric Tank Backup (Savings is Average)	.61 EF gas .92 Electric	SEF 1.30
			SEF 1.51
			SEF 1.81
			SEF 2.31
			SEF 3.01
703.6.1	Hardwired lighting	75% HE	100% HE
703.6.2	Recessed lighting	none	
703.6.3	E* appliances - Refrigerator	Consistent with BA and RESNET Estimates	
	Dishwasher		
	Washing Machine		High Efficiency
703.6.4	Induction cooktop		
703.7.1	Sun-tempered design	Standard reference house design	
703.7.2	Window shading (active)		
703.7.3	Passive cooling design		
703.7.4	Passive heating (mass)		

For Section 703 practices that have multiple performance levels, simulations are performed using the minimum efficiency option and the highest performing option (that can be simulated). From these two data points, a linear fit is applied to the cost savings to obtain savings for the middle performance levels.

All energy savings used in this analysis are based on cost and on a whole-house basis.

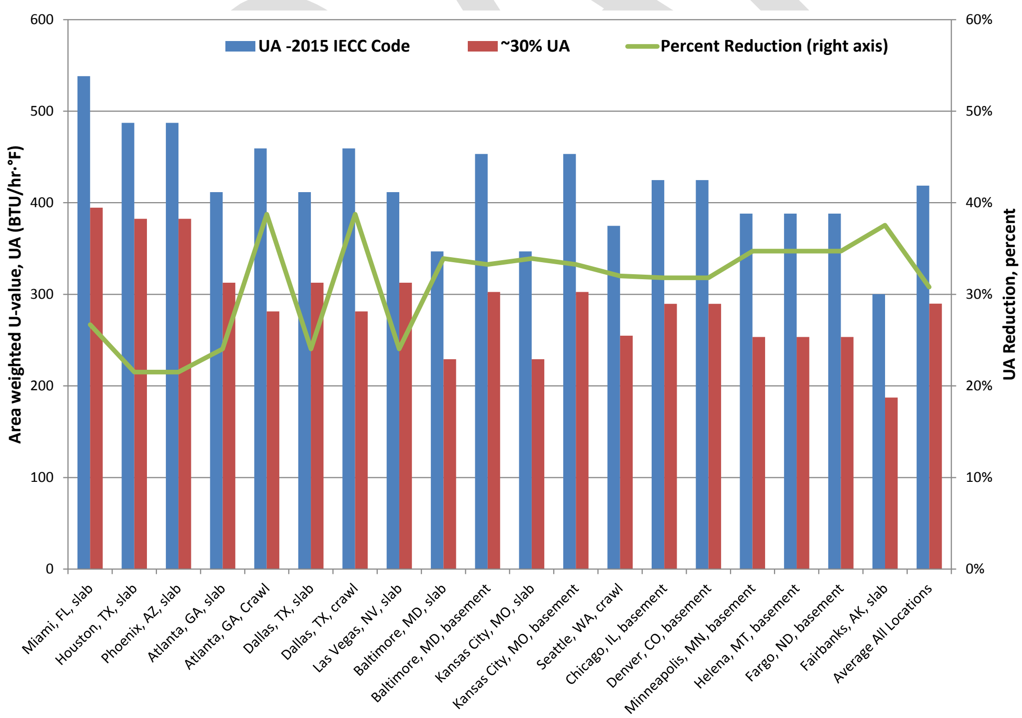
Individual 703 Practices Modeling Details

UA reductions: Decreases in the building UA are achieved through increases in the thermal insulation combination of wall, window, foundation, and ceiling surfaces. The overall UA value is determined through an area-weighted average calculation. This analysis used standard wall assemblies in the software (either REMrate or REScheck may be used for this calculation) and varied insulation levels for the cavity and sheathing as applicable. The data points calculated were based on an envelope UA reduction average for the 19 simulation sites of 31% but with a range from 22% to 29% depending on the climate zone. Features associated with this UA reduction for each climate zone are shown in Table 7.

Table 7. Climate Specific Envelope Features for ~30% UA Reduction

Climate Zone	Slab edge	Crawl wall	Basement	walls	Ceiling	Windows
CZ 1	R-0			R19	R38	0.38/0.25
CZ 2	R-0			R15+5	R49	0.38/0.25
CZ 3	R-0	R19		R23+7.5	R49	0.30/0.25
CZ 4	R10		R13+5	R23+10	R49	0.25/0.40
CZ 4C, 5		R19	R13+5	R23+10	R49	0.25/0.40
CZ 6			R23+5	R23+15	R60	0.22/0.40
CZ 7			R23+5	R23+15	R60	0.22/0.40
CZ 8	R15			R23+20	R60	0.22/0.40

The UA comparison for each climate zone and associated savings percentage is shown in Figure 7.



Note: Baseline crawlspace uses floor insulation; Improved crawl uses wall insulation.

Figure 7. UA Comparison for 2015 IECC and ~30% Improvement

Using the percent savings for each climate zone at the ~30% savings level, a linear fit algorithm is used to calculate intermediate improvements down to the baseline UA. A check for performance at approximately the 5% UA improvement level validates the savings at the lower end of the range.

Windows used in the analysis are the best performing windows available in the proposed NGBS-2015. Wall insulation improvements were based on 2x6 construction with blown cavity insulation and with the addition of exterior insulation to increase wall thermal values. Ceiling insulation levels were limited to R60.

Mass walls and radiant barrier sheathing: Mass wall construction and celling radiant barrier technologies were applied to the base building n in representative climates to determine the level of energy savings. Simulation estimates resulted in less than 1.5% savings in a range of climates.

Space conditioning equipment: Furnaces, A/C units, and air and ground source heat pumps, were modeled using the same methodology of determining performance with the highest equipment performance that had models available in the software. Due to the unique performance characteristics of heat pumps for example, that are dependent on outdoor air temperature, and the manufacturer specific ratings, the built-in software models have been developed to represent actual equipment performance and generally represent a range of performance matching the NGBS performance levels.

Ground source heat pumps are unique in that the models used in the software do not have as high a performance level as equipment in the NGBS. In this case, the highest performing equipment is used and post processing linear fit algorithms are used to estimate savings for higher performing equipment.

Parametric models for heating and cooling equipment are shown in Table 8.

Table 8. Equipment performance features used in simulations

Equipment	Baseline	Performance Levels	
Furnace, AFUE	80%	80%	98%
Air Conditioner (split system), SEER	14	15	21
Air Source Heat Pump (split system), SEER/HSPF	14/8.2	15/8.5	19/9.5
Ground Source Heat Pump, EER/COP[A]	ASHP 14/8.2	16.6/3.6	19.4/3.8

[A] GSHP simulations use low conductivity soil and standard grout.

Energy savings attributed to ground source heat pump technology is averaged from a baseline house with an air source heat pump and a baseline house with a gas furnace installed. This is a change from the original estimate that used only an air source heat pump technology in cold climates as the reference. Minimum efficiency heat pump technology will rely on resistance heat backup as needed based on the outdoor temperature, and therefore use of this baseline only may overstate cost savings in cold climates. GSHP systems modelled in REM/Rate and BEopt provided similar savings levels.

Gas engine heat pump and water cooled heat pump technologies were not modeled directly in the software.

Duct system: The prescriptive practice for ducts in conditioned space was modeled directly. The energy savings associated with this feature was then applied to the ductless heating and cooling savings (as applied to ducts only) based on the proportion of the heat pump cost for heating and cooling.

Domestic water heating: Energy savings attributed to water heating equipment requires both simulation results and post processing analysis. Equipment modeled for each climate includes:

- Gas tank, 40 gallon, 0.61 EF
- Electric tank, 50 gallon, 0.92 EF
- Gas tankless, 0.96 EF
- Heat pump water heater (HPHW)
- 64 sf closed loop solar system with pump

Using these simulation results, hot water loads are calculated and applied to higher water heating efficiencies to determine savings. This methodology was used to reduce the number of parametric simulation runs. Using targeted checks with additional simulation runs, the methodology was shown to have acceptable accuracy.

Heat pump water heaters (HPWH) are a unique technology applied to domestic water heating and now available from most major water heater manufacturers. Simulation of the heat pump water heating technology was performed using BEopt software running the Energy Plus simulation engine. When place to the interior of the home, i.e. inside the house for slab or crawl space foundations and otherwise in the basement. HPWH technology uses indoor air for water heating and thus makes the house cooler. The operation of the HPWH can save cooling energy and increase heating energy. The simulations account for this associated energy use/savings and are included in the whole-house analysis.

A post processing algorithm that uses the water heating energy delivered to the house serves as the calculation base for the actual energy factor (EF) of the HPWH. As expected, in colder climates, this calculated EF decreases since the hot water load increases due to colder incoming water temperatures. However, the cost savings for the heat pump water heater, when compared with an electric water heater base, was similar for all climates as shown in Figure 8.

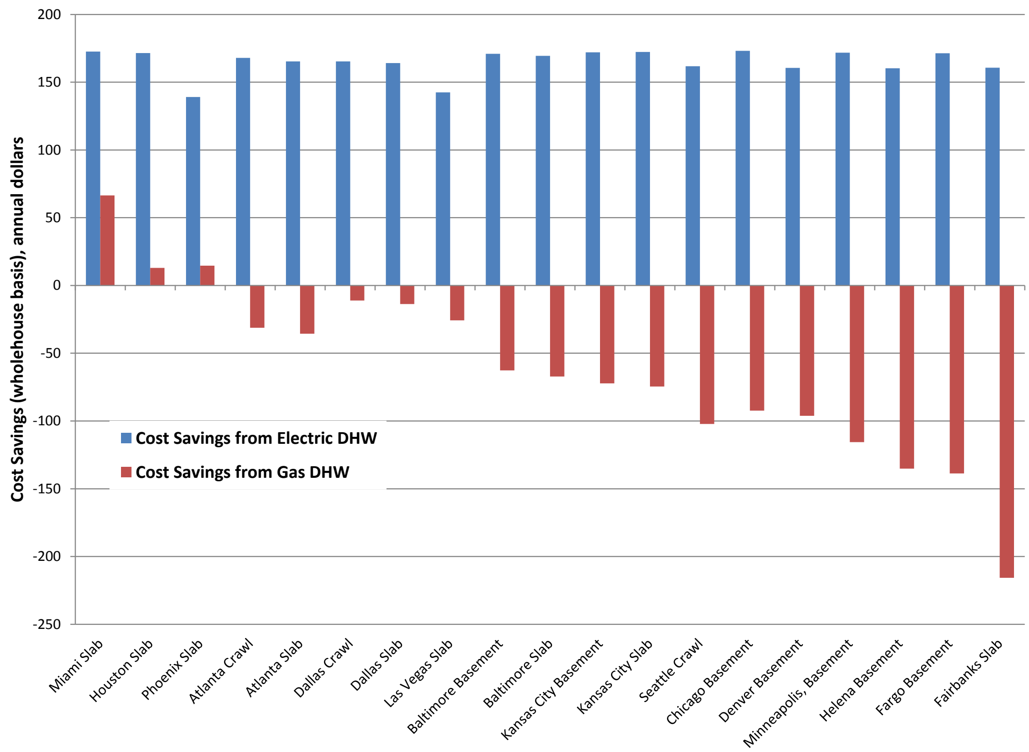


Figure 8. HPWH Cost Savings from Respective Base DHW

In terms of whole house cost and savings, Figure 9 charts the energy costs when using Gas or Electric baseline water heaters and a HPWH, as well as the savings percentage, in each climate.

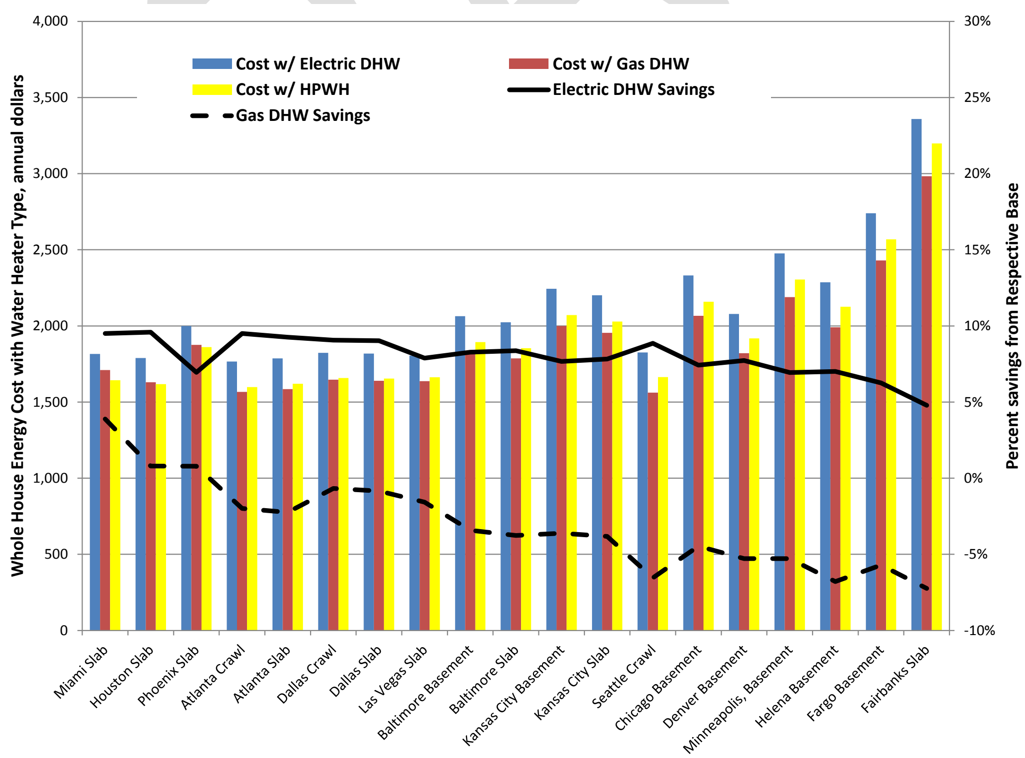


Figure 9. HPWH Energy Use and Savings Comparison

One significant issue with the application of HPWH technology is the base technology that it replaces. HPWH units are designed to replace standard water heating tanks except with an air flow requirement which precludes them from use in small closets. Since the HPWH can replace either gas or electric units, the baseline selected is an average of both technologies. This averaging however will reduce the cost savings since HPWH technology will often cost more to operate than gas water heating technology.

One other estimate that was made is the assignment of the energy factor for the units. The NGBS uses various levels of energy factors for the heat pump technology. An "actual" EF can be calculated for the unit operation and then used in conjunction with a linear fit estimation for other energy factors. However this approach was found to overestimate savings in cold climates due to the initial low EF calculation. Rather, the savings estimates from the simulation were assigned to the mid-level performance of the HPWH and a simple factor was applied for lower and higher energy factor units to adjust the savings.

Solar water heating adds another layer of complexity as well. Similar to the HPWH, the solar system may be applied to either gas or electric water heating baselines and as such is averaged for each climate. The reason for this averaging is demonstrated in Figure 10.

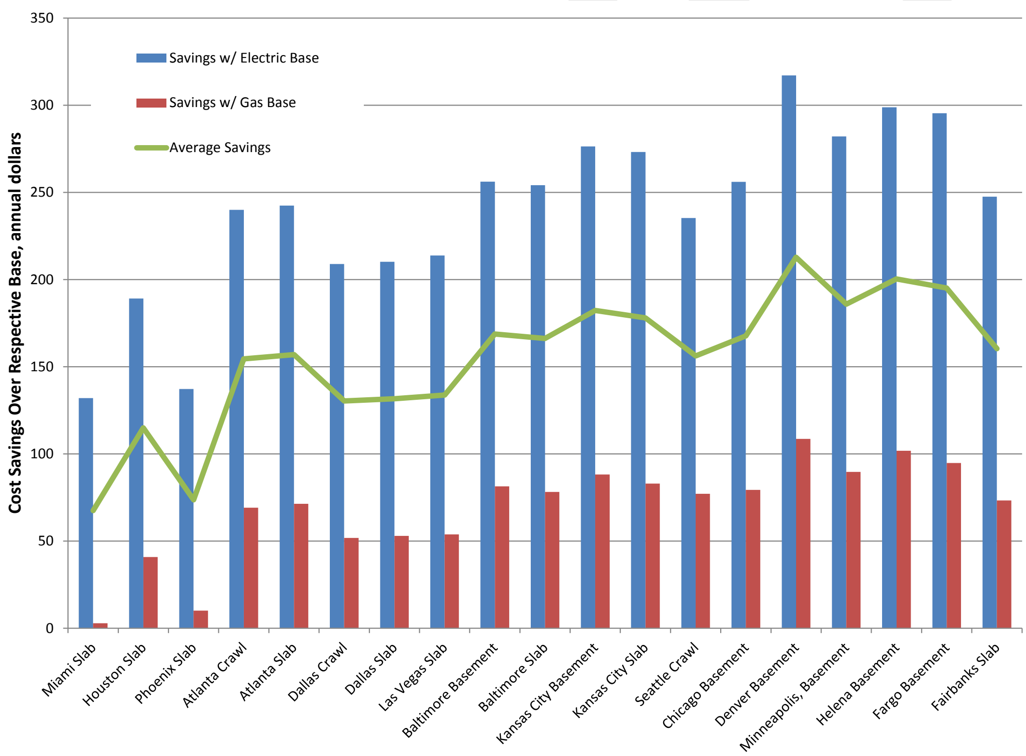


Figure 10. Cost Savings from Solar DHW System with Respective Base DHW Tanks

A solar energy factor is calculated from the simulation data using the SRCC Thermal Performance Rating methodology[14]. Figure 11 shows the calculated SEF for the same size solar system applied to different climates.

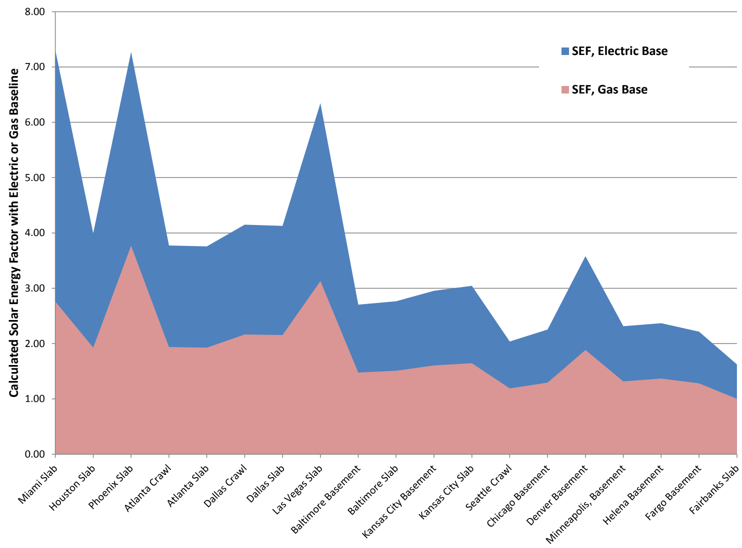


Figure 11. Solar Energy Factor Calculations for Climate Using Constant System Size

Clearly the SEF decreases in the colder climates; however, this matches the increase in water heating load. Figure 12 and Figure 13 show that the solar hot water production is somewhat consistent across climates, however, the portion of hot water energy that remains for backup heating is significantly higher in colder climates. Whereas a larger thermal system would provide little additional benefit in warmer climates, there remains a benefit for increasing the solar thermal system in colder climates.

Practices not modeled: A number of prescriptive practices were not modeled due either to complexity (i.e. gas engine heat pumps) or due to the presumed variation in use (i.e. ceiling fans and whole house ventilation fan). Other prescriptive practices such as submeter in multiunit buildings do not have a clear calculation path to energy savings and are not modeled, rather rely on previous estimates for savings attributed to the technology.

Similarly, recessed lighting is not modeled as the energy savings for sealed fixtures can generally be found in the air tightness of the home. Some Energy Star appliances were not modeled as the energy savings is minimal for refrigerators and dishwashers and the equipment is commonly available. Induction cooktops have an estimated savings from the previous analysis and has not been modeled.

Estimates for non-modeled Practices: Practices that either resulted in complex models or where the technology application is less defined were estimated for energy cost savings. The sun-tempered design, window shading (active), passive cooling design, and passive heating (mass) are examples. A few test cases were run which requires a reorientation of the home and a change in window area and placement.

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[14] Solar Rating & Certification Corporation (SRCC).
See www.solar-rating.org/facts/system_ratings.html#RATING for information on rating methodology.

The resultant savings were similar to estimates made in the analysis for the NGBS-2012 and so were left in place for this analysis.

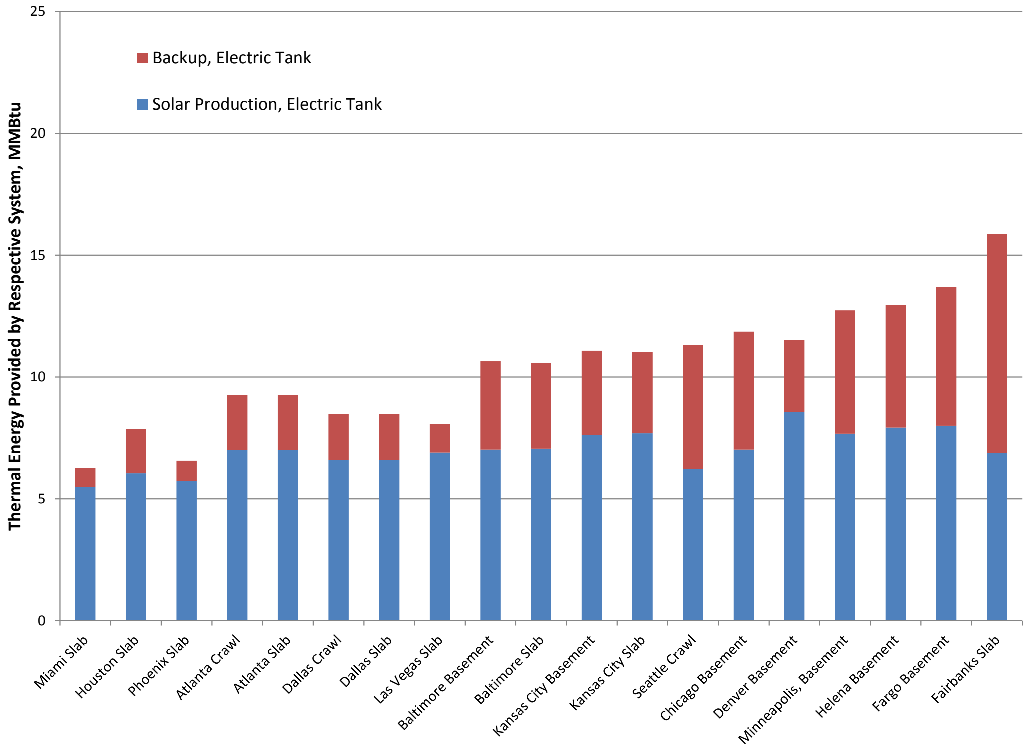

Figure 12. Solar and Backup Energy for DHW, Electric Tank

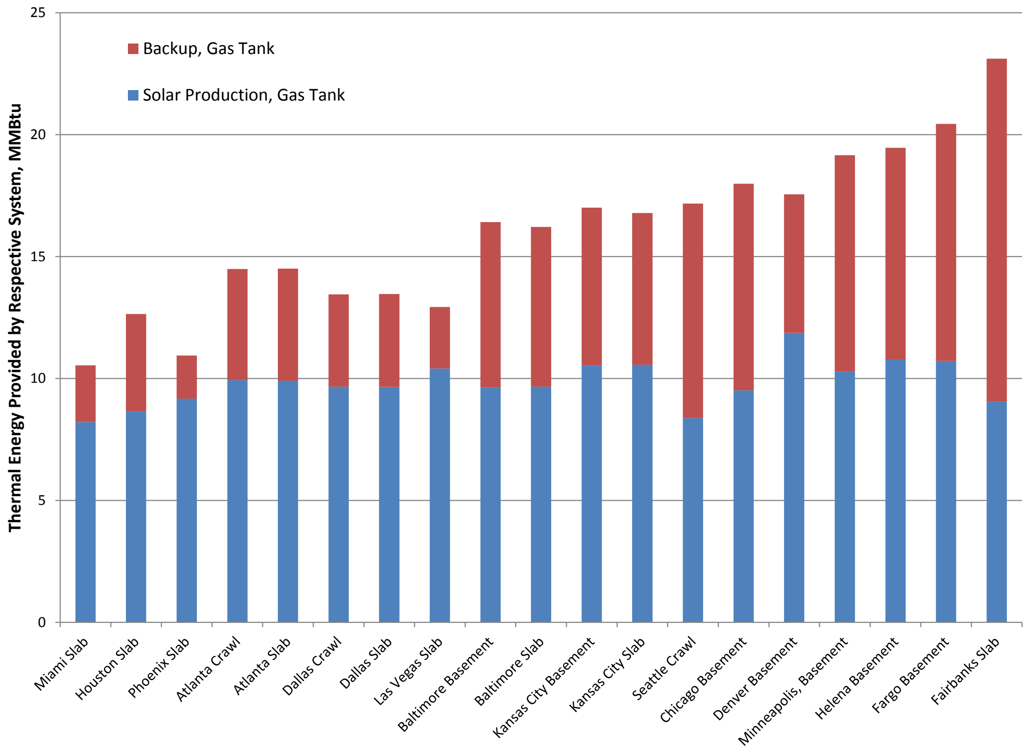

Figure 13. Solar and Backup Energy for DHW, Gas Tank

Selection of features for an approximate 30% cost savings home

Use of the prescriptive practices in Chapter 7 of the NGBS allows builders and designers to select combinations of energy features that lead to a level of merit savings. The selected features are additive and to the extent possible in this analysis, will align with the energy savings from software simulations.

Similar to the methodology used in the development of the NGBS-2012, a set of features have been selected to represent a high performing home and simulated to assess the level of energy savings. The results of this analysis were a combination of features to achieve approximately 30% energy savings over the 2015 IECC baseline home design (Table 9).

Table 9. Selected Features for a High Performing Home Design

Feature	CZ 1	CZ 2	CZ 3	CZ 4	CZ 4C & 5	CZ 6	CZ 7	CZ 8
Slab edge	R-0	R-0	R-0	R10				R15
Crawl wall			R19		R19			
Basement[A]				R13+5	R13+5	R23+5	R23+5	
Walls[1]	R19	R15+5	R23+7.5	R23+10	R23+10	R23+15	R23+15	R23+20
Ceiling	R38	R49	R49	R49	R49	R60	R60	R60
Windows[B]	0.38/0.25	0.38/0.25	0.30/0.25	0.25/0.40	0.25/0.40	0.22/0.40	0.22/0.40	0.22/0.40
Infiltration	3 ACH50	3 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50
Heating	9.0 HSPF	92.5 AFUE	92.5 AFUE	94 AFUE	94 AFUE	96 AFUE	96 AFUE	96 AFUE
Cooling	17 SEER	18 SEER	18 SEER	18 SEER	18 SEER	15 SEER	15 SEER	14 SEER
Water Heating[C]	HPWH	96% EF	96% EF	96% EF	96% EF	96% EF	96% EF	96% EF
Duct Location[D]	Con. Space	Con. Space	Con. Space	Con. Space	Con. Space	Con. Space	Con. Space	Con. Space
Duct Leakage[D]	72T/36O	72T/36O	72T/36O	72T/36O	72T/36O	72T/36O	72T/36O	72T/36O
Lighting	100% HE	100% HE	100% HE	100% HE	100% HE	100% HE	100% HE	100% HE
Washer	HE	HE	HE	HE	HE	HE	HE	HE
REM savings over base	30%	28%	28%	32%	31%	35%	37%	42%
HERS Index	51	49	42.6	43	45	41	38	33%
Minimum[E] Savings for climate		27%	26%	31%	28%	34%		
Maximum[E] savings for climate		29%	30%	33%	33%	35%		

[A] Cavity R-value + sheathing R-value; [2]Window U-value/solr heat gain coefficient
[B] Heat pump water heater in CZ1, otherwise a 95% condensing tankless unit in CZ2 – CZ8
[C] Conditioned space, 72cfm Total leakage, 36cfm outside leakage
[D] Where multiple simulation locations in a climate zone

COST SAVINGS FOR PRESCRIPTIVE PRACTICES – SUMMARY RESULTS

Data from simulation results and post processing analysis is rolled up into a summary for each location modeled (Figure 14 and Figure 15). These data are the result of parametric simulations of individual practices and are not based on multiple technologies being employed at the same time. Where values are missing, estimates will be made for the specific technologies based on the above discussion. Negative values indicate higher energy costs for the practice.

The initial summary rollup tables include at the top rows:

- Sum of ~30% Features - the features selected for an approximate 30% savings, are shown in green highlight (see Table 9)
- BEopt Simulation Savings - taken from simulations using the selected features
- REM Simulation Savings - taken from simulations using the selected features
- REM:Beopt ratio – compares REM result with BEopt
- REM:Sum ratio – compares REM with the Sum of the individual features
- Beopt:Sum ratio – compares BEopt with the Sum of the individual features

Hers Index at ~30% level – taken directly from the REM analysis

Proposed 2015 NGBS Section	Provision	Base Reference 2015 IECC	1A hot, humid Miami, Florida Slab Foundation	2A hot, humid Houston, Texas Slab Foundation	2B hot, dry Phoenix, Arizona Slab Foundation	3A hot, humid Atlanta, Georgia Slab Foundation	3A hot, humid Atlanta, Georgia Vented Crawlspace	3A hot, humid Dallas, Texas Slab Foundation	3A hot, humid Dallas, Texas Vented Crawlspace	3B hot, dry Las Vegas, Nevada Slab Foundation	4A mixed, humid Baltimore, Maryland Slab Foundation	4A mixed, humid Baltimore, Maryland Basement
	Sum of ~30% Features		27%	26%	26%	29%	30%	28%	31%	29%	34%	33%
	BEopt Simulation Savings		28%	26%	29%	27%	27%	27%	27%	28%	30%	29%
	REM Simulation Savings		30%	27%	29%	28%	26%	29%	26%	30%	33%	31%
	REM:Beopt ratio		108%	103%	101%	107%	99%	106%	95%	107%	110%	106%
	REM:Sum ratio		111%	104%	113%	99%	88%	102%	84%	104%	97%	92%
	Beopt:Sum ratio		102%	101%	112%	93%	89%	96%	89%	97%	88%	87%
	Hers Index at ~30% level		51	51	47	43	40	45	42	43	42	44
703.2.1	0 to < 5% UA improvement (Base)	2015 IECC	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	5% to < 10% UA improvement		0.68%	1.27%	1.57%	1.47%	1.37%	1.38%	1.39%	1.55%	1.80%	1.72%
	10% to < 15% UA improvement		1.37%	2.55%	3.13%	2.95%	2.74%	2.77%	2.78%	3.10%	3.61%	3.43%
	15% to < 20% UA improvement	per location	2.05%	3.82%	4.70%	4.42%	4.12%	4.15%	4.16%	4.64%	5.41%	5.15%
	20% to < 25% UA improvement	Use REMrate	2.74%	5.10%	6.27%	5.90%	5.49%	5.53%	5.55%	6.19%	7.22%	6.87%
	25% to < 30% UA improvement	for levels	3.42%	6.37%	7.83%	7.37%	6.86%	6.92%	6.94%	7.74%	9.02%	8.58%
	30% to < 35% UA improvement		4.11%	7.65%	9.40%	8.85%	8.23%	8.30%	8.33%	9.29%	10.83%	10.30%
	>= 35% UA improvement		4.79%	8.92%	10.97%	10.32%	9.61%	9.68%	9.72%	10.83%	12.63%	12.02%
	UA Simulation Calibration	per REM calc	3.70%	5.61%	6.89%	7.08%	9.88%	6.64%	10.00%	7.43%	12.27%	11.33%
703.2.2	Insulation installation quality											
703.2.3	Mass walls (< 6")	no mass										
	Mass walls (≥ 6")	no mass	0.16%	0.79%	0.55%	-0.36%				1.20%		1.02%
703.2.4	Radiant barrier	no RB	1.04%	0.88%	1.27%	0.77%				1.02%		0.54%
703.2.5	Envelope leakage, ACH50	5										
		4	0.63%	1.25%	0.96%							
		3	0.99%	2.17%	1.58%							
		2	1.35%	3.08%	2.21%	1.64%	1.32%	1.70%	1.39%	1.40%	2.28%	2.11%
		1	1.71%	4.00%	2.83%	2.84%	2.26%	2.89%	2.39%	2.40%	3.96%	3.46%
703.2.6.2.1(a)	Fenestration level 1	2015 IECC	0.14%	0.22%	0.27%	1.14%	1.11%	1.04%	0.98%	1.18%	1.48%	1.68%
703.2.6.2.1(b)	Femestration level 2	Table 402.1.2	0.77%	1.26%	1.41%	2.35%	2.24%	2.09%	1.95%	2.32%	2.10%	2.41%
703.2.6.2.1(c)	Femestration level 3										3.02%	3.40%
703.3.1	Combo heating system											
703.3.2	Gas & Oil Furnace efficiency	≥ 85		0.62%	0.26%	1.13%	1.00%	0.83%	0.78%	0.66%	1.65%	1.69%
		≥ 90		1.24%	0.52%	2.26%	2.01%	1.66%	1.55%	1.32%	3.29%	3.37%
		≥ 92		1.49%	0.62%	2.72%	2.41%	2.00%	1.86%	1.58%	3.95%	4.05%
		≥ 94		1.74%	0.72%	3.17%	2.81%	2.33%	2.17%	1.84%	4.61%	4.72%
		≥ 96		1.99%	0.83%	3.62%	3.21%	2.66%	2.48%	2.11%	5.27%	5.40%
		≥ 98		2.23%	0.93%	4.07%	3.61%	2.99%	2.79%	2.37%	5.93%	6.07%
	Boiler efficiency	≥ 85		0.53%	0.22%	0.96%	0.85%	0.71%	0.66%	0.56%	1.40%	1.43%
		≥ 90		1.06%	0.44%	1.92%	1.71%	1.41%	1.32%	1.12%	2.80%	2.87%
		≥ 92		1.27%	0.53%	2.31%	2.05%	1.70%	1.58%	1.34%	3.36%	3.44%
		≥ 94		1.48%	0.62%	2.69%	2.39%	1.98%	1.85%	1.57%	3.92%	4.01%
		≥ 96		1.69%	0.70%	3.08%	2.73%	2.26%	2.11%	1.79%	4.48%	4.59%
703.3.3	Heat Pump Heating	8.5 HSPF	0.01%	0.52%	0.22%	0.95%	0.82%	0.72%	0.65%	0.56%	1.37%	1.34%
		9.0 HSPF	0.04%	1.65%	0.36%	2.98%	2.93%	2.13%	2.47%	1.60%	3.12%	3.42%
		9.5 HSPF	0.07%	2.77%	0.50%	5.01%	5.03%	3.53%	4.30%	2.64%	4.87%	5.49%
		10 HSPF	0.09%	3.90%	0.64%	7.04%	7.13%	4.94%	6.12%	3.68%	6.62%	7.57%
	Gas Engine Heat Pump Heating	> 1.3 COP at 47F										
703.3.4	Electric Air Conditioner and Heat Pump Cooling	≥ 14 SEER	-0.13%	1.09%	2.99%	0.38%	0.35%	0.94%	0.67%	1.07%	0.32%	0.15%
		≥ 15 SEER	1.49%	2.15%	3.36%	1.14%	1.29%	1.82%	1.93%	2.09%	0.80%	0.83%
		≥ 17 SEER	4.72%	4.27%	4.12%	2.66%	3.18%	3.59%	4.44%	4.14%	1.78%	2.19%
		≥ 19 SEER	7.95%	6.40%	4.87%	4.18%	5.07%	5.36%	6.96%	6.18%	2.76%	3.55%
		≥ 21 SEER	11.19%	8.52%	5.63%	5.70%	6.95%	7.13%	9.48%	8.23%	3.74%	4.91%
	Gas Engine Heat Pump Cooling	> 1.2 COP at 95F										
703.3.5	Water Source and cooled A/C	≥ 4 COP, 15 EER										
703.3.6	Ground Source Heat Pump	14.1 EER, 3.3 COP	-8.83%	-3.75%	-6.51%	-2.38%	-2.93%	-1.77%	-2.01%	-5.99%	0.38%	1.62%
		15 EER, 3.5 COP	-7.10%	-1.47%	-4.19%	-0.14%	-0.51%	0.55%	0.29%	-3.67%	2.80%	4.09%
		16.2 EER, 3.6 COP	-4.80%	0.41%	-1.68%	1.25%	1.09%	2.23%	2.02%	-1.77%	4.13%	5.43%
		24 EER, 4.3 COP	10.18%	13.00%	14.84%	10.81%	11.95%	13.57%	13.70%	10.93%	13.35%	14.73%
		28 EER, 4.8 COP	17.86%	20.44%	23.79%	17.05%	18.90%	20.59%	20.81%	18.46%	19.68%	21.14%
703.3.7	E* ceiling fans	Standard										
703.3.8	whole house ventilation fan											
703.3.9	Submeter in multiunit			3.36%	2.59%	2.38%	2.54%	2.56%	2.64%	2.48%	1.88%	2.17%
703.4.1	Ductless heating system	Standard duct	0.03%	1.30%	0.57%	2.84%	1.99%	1.85%	1.44%	1.53%	3.73%	3.61%
703.4.2	Ductless cooling system	install and	3.30%	2.81%	4.54%	1.74%	1.50%	2.46%	2.18%	2.99%	1.05%	0.95%
703.4.3	Duct installation (interior+)	location	3.33%	4.11%	5.11%	4.58%	3.49%	4.31%	3.62%	4.52%	4.78%	4.57%
703.4.4	Duct leakage 6% out	< 4cfm/100sf										
703.5.1	Gas Water Heating	0.67 to < 0.80 EF		1.29%	1.16%	1.07%	1.14%	1.15%	1.18%	1.11%	0.84%	0.97%
	(Use 40 Gallon for NGBS design)	≥ 0.80		1.88%	1.70%	1.56%	1.66%	1.68%	1.73%	1.63%	1.23%	1.42%
	Large storage or Instaneous	≥ 0.90		2.87%	2.59%	2.38%	2.54%	2.56%	2.64%	2.48%	1.88%	2.17%
	Large storage or Instaneous	≥ 0.95		3.36%	3.03%	2.79%	2.98%	3.00%	3.09%	2.91%	2.20%	2.54%
	Electric Resistance Water	≥ 0.95	0.40%	0.51%	0.38%	0.60%	0.61%	0.54%	0.54%	0.52%	0.61%	0.60%
	Electric Instantaneous Water	≥ 0.97	0.66%	0.84%	0.62%	0.99%	1.00%	0.89%	0.88%	0.85%	0.99%	0.98%
	Heat Pump Water Heater	1.5 to < 2.0	7.13%	3.89%	2.90%	2.63%	2.82%	3.07%	3.15%	2.37%	1.73%	1.82%
		2.0 to < 2.2	9.50%	5.19%	3.87%	3.51%	3.76%	4.09%	4.20%	3.16%	2.31%	2.43%
		≥ 2.2	10.45%	5.71%	4.26%	3.86%	4.13%	4.50%	4.62%	3.48%	2.54%	2.67%
703.5.2	Desuperheater		10.00%	8.00%	8.00%	5.00%	5.00%	5.00%	5.00%	5.00%	4.00%	4.00%
703.5.3	Drainwater heat recovery		0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%
703.5.4	Indirect water heater											
703.5.5	Solar Water Heating Gas or Electric Tank Backup (Savings is Average)	SEF 1.30	0.43%	1.31%	0.26%	2.09%	2.05%	1.41%	1.37%	0.86%	2.97%	3.09%
		SEF 1.51	0.67%	1.87%	0.40%	2.95%	2.90%	2.00%	1.96%	1.23%	4.20%	4.36%
		SEF 1.81	1.01%	2.67%	0.58%	4.18%	4.11%	2.86%	2.79%	1.75%	5.95%	6.17%
		SEF 2.31	1.58%	4.00%	0.89%	6.23%	6.13%	4.28%	4.19%	2.63%	8.86%	9.19%
		SEF 3.01	2.38%	5.87%	1.33%	9.10%	8.96%	6.27%	6.14%	3.85%	12.95%	13.42%
703.6.1	Hardwired lighting	100% HE	1.38%	1.54%	1.34%	1.58%	1.60%	1.53%	1.52%	1.53%	1.40%	1.37%
703.6.2	Recessed lighting											
703.6.3	E* appliances - Refrigerator	Consistent with										
	Dishwasher	BA and RESNET										
	Washing Machine	Estimates	1.83%	2.04%	1.78%	2.10%	2.12%	2.03%	2.02%	2.03%	1.86%	1.82%
703.6.4	Induction cooktop											
703.7.1	Sun-tempered design	standard			1.79%			0.57%				
703.7.2	Window shading (active)	reference										
703.7.3	Passive cooling design	house			2.11%			0.84%				
703.7.4	Passive heating (mass)	design			1.30%			-1.04%				

Figure 14. Summary of Initial Energy Cost Savings for Prescriptive Practices (1)

Proposed 2015 NGBS Section	Provision	Base Reference 2015 IECC	4A mixed, humid Kansas City, Missouri Slab Foundation	4A mixed, humid Kansas City, Missouri Basement	4C marine Seattle, Washington Vented Crawlspace	5A cold, humid Chicago, Illinois Basement	5B cold, dry Denver, Colorado Basement	6A cold humid Minneapolis, Minnesota Basement	6B cold, dry Helena, Montana Basement	7 very cold Fargo, North Dakota Basement	8 extreme cold Fairbanks, Alaska Slab
	Sum of ~30% Features		**36%**	**35%**	**33%**	**34%**	**31%**	**34%**	**33%**	**36%**	**40%**
	BEopt Simulation Savings		**32%**	**31%**	**26%**	**29%**	**28%**	**30%**	**28%**	**31%**	**36%**
	REM Simulation Savings		**33%**	**32%**	**28%**	**33%**	**31%**	**35%**	**34%**	**37%**	**42%**
	REM:Beopt ratio		**105%**	**104%**	**107%**	**112%**	**113%**	**118%**	**121%**	**120%**	**115%**
	REM:Sum ratio		**92%**	**90%**	**86%**	**97%**	**101%**	**103%**	**105%**	**105%**	**104%**
	Beopt:Sum ratio		**87%**	**87%**	**80%**	**86%**	**89%**	**87%**	**86%**	**87%**	**91%**
	Hers Index at ~30% level		**41**	**43**	**44**	**44**	**46**	**40**	**42**	**38**	**33**
703.2.1	0 to < 5% UA improvement (Base)	2015 IECC	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	5% to < 10% UA improvement	per location Use REMrate for levels	1.92%	1.77%	1.73%	1.65%	1.58%	1.47%	1.54%	1.40%	1.73%
	10% to < 15% UA improvement		3.84%	3.54%	3.45%	3.30%	3.17%	2.94%	3.07%	2.81%	3.46%
	15% to < 20% UA improvement		5.75%	5.30%	5.18%	4.95%	4.75%	4.40%	4.61%	4.21%	5.18%
	20% to < 25% UA improvement		7.67%	7.07%	6.90%	6.60%	6.34%	5.87%	6.15%	5.61%	6.91%
	25% to < 30% UA improvement		9.59%	8.84%	8.63%	8.25%	7.92%	7.34%	7.69%	7.01%	8.64%
	30% to < 35% UA improvement		11.51%	10.61%	10.35%	9.91%	9.50%	8.81%	9.22%	8.42%	10.37%
	>= 35% UA improvement		13.42%	12.38%	12.08%	11.56%	11.09%	10.28%	10.76%	9.82%	12.09%
	UA Simulation Calibration	per REM calc	13.04%	11.67%	12.08%	10.57%	10.14%	10.28%	10.76%	10.10%	13.13%
703.2.2	Insulation installation quality										
703.2.3	Mass walls (< 6")	no mass			0.16%						
	Mass walls (≥ 6")	no mass			0.83%	2.01%					
703.2.4	Radiant barrier	no RB			0.21%	0.54%				0.50%	
703.2.5	Envelope leakage, ACH50	5									
		4									
		3									
		2	2.65%	2.79%	1.82%	2.91%	1.84%	3.34%	2.48%	4.27%	3.50%
		1	4.86%	4.95%	3.07%	5.20%	3.10%	5.87%	4.24%	7.59%	5.77%
703.2.6.2.1(a)	Fenestration level 1	2015 IECC Table 402.1.2	1.62%	1.74%	1.43%	1.80%	1.78%	1.99%	1.99%	2.08%	1.89%
703.2.6.2.1(b)	Femestration level 2		2.28%	2.46%	1.80%	2.12%	2.11%	2.38%	2.48%	2.49%	2.31%
703.2.6.2.1(c)	Femestration level 3		3.27%	3.53%	2.37%	2.60%	2.60%	2.98%	3.21%	3.12%	2.94%
703.3.1	Combo heating system										
703.3.2	Gas & Oil Furnace efficiency	≥ 85	1.84%	1.86%	1.65%	2.12%	1.74%	2.31%	2.18%	2.58%	3.04%
		≥ 90	3.68%	3.73%	3.31%	4.23%	3.49%	4.61%	4.35%	5.16%	6.08%
		≥ 92	4.41%	4.48%	3.97%	5.08%	4.19%	5.53%	5.22%	6.19%	7.30%
		≥ 94	5.15%	5.22%	4.63%	5.92%	4.88%	6.46%	6.09%	7.22%	8.51%
		≥ 96	5.88%	5.97%	5.29%	6.77%	5.58%	7.38%	6.96%	8.25%	9.73%
		≥ 98	6.62%	6.71%	5.95%	7.62%	6.28%	8.30%	7.83%	9.29%	10.94%
	Boiler efficiency	≥ 85	1.56%	1.59%	1.41%	1.80%	1.48%	1.96%	1.85%	2.19%	2.58%
		≥ 90	3.13%	3.17%	2.81%	3.60%	2.97%	3.92%	3.70%	4.39%	5.17%
		≥ 92	3.75%	3.80%	3.37%	4.32%	3.56%	4.70%	4.44%	5.26%	6.20%
		≥ 94	4.38%	4.44%	3.94%	5.04%	4.15%	5.49%	5.18%	6.14%	7.24%
		≥ 96	5.00%	5.07%	4.50%	5.75%	4.74%	6.27%	5.92%	7.02%	8.27%
703.3.3	Heat Pump Heating	8.5 HSPF	1.50%	1.36%	1.28%	1.35%	1.20%	1.16%	1.04%	0.74%	0.56%
		9.0 HSPF	1.69%	3.01%	3.18%	3.18%	4.55%	3.66%	6.88%	7.65%	4.01%
		9.5 HSPF	1.89%	4.67%	5.07%	5.01%	7.91%	6.15%	12.71%	14.57%	7.45%
		10 HSPF	2.08%	6.32%	6.97%	6.85%	11.27%	8.64%	18.55%	21.49%	10.90%
	Gas Engine Heat Pump Heating	> 1.3 COP at 47F									
703.3.4	Electric Air Conditioner and Heat Pump Cooling	≥ 14 SEER	0.27%	0.10%	-0.03%	-0.05%	-0.06%	-0.14%	-0.22%	-0.14%	0.06%
		≥ 15 SEER	0.79%	0.83%	0.24%	0.52%	0.61%	0.37%	0.22%	0.26%	0.05%
		≥ 17 SEER	1.83%	2.29%	0.76%	1.65%	1.93%	1.39%	1.11%	1.05%	0.02%
		≥ 19 SEER	2.88%	3.76%	1.29%	2.77%	3.26%	2.41%	1.99%	1.84%	-0.01%
		≥ 21 SEER	3.92%	5.22%	1.81%	3.90%	4.59%	3.43%	2.88%	2.63%	-0.04%
	Gas Engine Heat Pump Cooling	> 1.2 COP at 95F									
703.3.5	Water Source and cooled A/C	≥ 4 COP, 15 EER									
703.3.6	Ground Source Heat Pump	14.1 EER, 3.3 COP	2.65%	4.33%	1.13%	6.55%	5.02%	9.76%	9.41%		
		15 EER, 3.5 COP	5.19%	6.90%	2.90%	8.96%	7.22%	12.13%	11.55%		
		16.2 EER, 3.6 COP	6.55%	8.27%	3.81%	10.20%	8.38%	13.33%	12.62%		
		24 EER, 4.3 COP	15.97%	17.77%	10.16%	18.85%	16.40%	21.70%	20.14%		
		28 EER, 4.8 COP	22.51%	24.38%	14.65%	24.96%	22.03%	27.66%	25.49%		
703.3.7	E* ceiling fans	Standard									
703.3.8	whole house ventilation fan										
703.3.9	Submeter in multiunit		2.10%	2.36%	1.70%	2.14%	2.49%	2.01%	2.04%	1.86%	0.94%
703.4.1	Ductless heating system	Standard duct install and location	4.02%	3.65%	5.02%	4.27%	3.96%	4.22%	3.98%	3.99%	8.12%
703.4.2	Ductless cooling system		0.89%	0.73%	0.47%	0.45%	0.61%	0.25%	0.15%	0.11%	0.05%
703.4.3	Duct installation (interior+)		4.91%	4.38%	5.49%	4.72%	4.56%	4.47%	4.14%	4.10%	8.16%
703.4.4	Duct leakage 6% out	< 4cfm/100sf									
703.5.1	Gas Water Heating	0.67 to < 0.80 EF	0.80%	0.90%	0.65%	0.82%	0.95%	0.77%	0.78%	0.71%	0.36%
	(Use 40 Gallon for NGBS design)	≥ 0.80	1.17%	1.32%	0.95%	1.20%	1.39%	1.12%	1.14%	1.04%	0.53%
	Large storage or Instaneous	≥ 0.90	1.79%	2.01%	1.45%	1.83%	2.12%	1.72%	1.74%	1.58%	0.80%
	Large storage or Instaneous	≥ 0.95	2.10%	2.36%	1.70%	2.14%	2.49%	2.01%	2.04%	1.86%	0.94%
	Electric Resistance Water	≥ 0.95	0.58%	0.58%	0.72%	0.59%	0.65%	0.60%	0.66%	0.58%	0.55%
	Electric Instantaneous Water	≥ 0.97	0.95%	0.94%	1.18%	0.97%	1.05%	0.98%	1.08%	0.95%	0.90%
	Heat Pump Water Heater	1.5 to < 2.0	1.50%	1.52%	0.87%	1.11%	0.92%	0.62%	0.08%	0.20%	-0.92%
		2.0 to < 2.2	2.01%	2.03%	1.16%	1.48%	1.22%	0.83%	0.11%	0.27%	-1.22%
		≥ 2.2	2.21%	2.23%	1.28%	1.62%	1.34%	0.91%	0.12%	0.30%	-1.35%
703.5.2	Desuperheater		4.00%	4.00%	3.00%	3.00%	3.00%	2.00%	2.00%	1.00%	1.00%
703.5.3	Drainwater heat recovery		0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%
703.5.4	Indirect water heater										
703.5.5	Solar Water Heating Gas or Electric Tank Backup (Savings is Average)	SEF 1.30	2.52%	2.68%	5.13%	3.50%	2.70%	3.55%	4.04%	3.58%	4.15%
		SEF 1.51	3.57%	3.78%	7.23%	4.95%	3.80%	5.02%	5.69%	5.07%	5.90%
		SEF 1.81	5.06%	5.35%	10.23%	7.03%	5.36%	7.11%	8.06%	7.19%	8.41%
		SEF 2.31	7.54%	7.97%	15.24%	10.48%	7.96%	10.60%	11.99%	10.72%	12.59%
		SEF 3.01	11.02%	11.64%	22.26%	15.33%	11.60%	15.49%	17.51%	15.66%	18.44%
703.6.1	Hardwired lighting	100% HE	1.28%	1.25%	1.60%	1.21%	1.37%	1.14%	1.26%	1.03%	0.84%
703.6.2	Recessed lighting										
703.6.3	E* appliances - Refrigerator	Consistent with BA and RESNET Estimates									
	Dishwasher										
	Washing Machine		1.70%	1.67%	2.13%	1.61%	1.83%	1.52%	1.67%	1.37%	1.12%
703.6.4	Induction cooktop										
703.7.1	Sun-tempered design	standard reference house design									
703.7.2	Window shading (active)										
703.7.3	Passive cooling design										
703.7.4	Passive heating (mass)										

Figure 15. Summary of Initial Energy Cost Savings for Prescriptive Practices (2)

The summary results of the selected features are graphically shown in Figure 16. The results indicate consistency between the software in the warmer climates with somewhat larger differences in the cold climates.

Based on this analysis, a calibration factor is applied to align the REM results with the Sum of the features results. This methodology allows for consistent results from selection of individual technologies to align more closely with simulation results of packages. The calibration factor however, relies on the selected features but is applied to all practices. Figure 17 shows the results of application of the calibration factor.

The simulation results are calibrated to the REMrate analysis leaving the BEopt results unchanged. This was done purposefully since REMrate is a commonly used software package for NGBS verifiers.

The draft prescriptive path points rollup summary that is provided to the Task Group responsible for the Chapter 7 Energy Efficiency Chapter 7 of the NGBS is shown in Figure 18. The Task Group will review this draft table and make recommendations for the standard to maintain consistency.

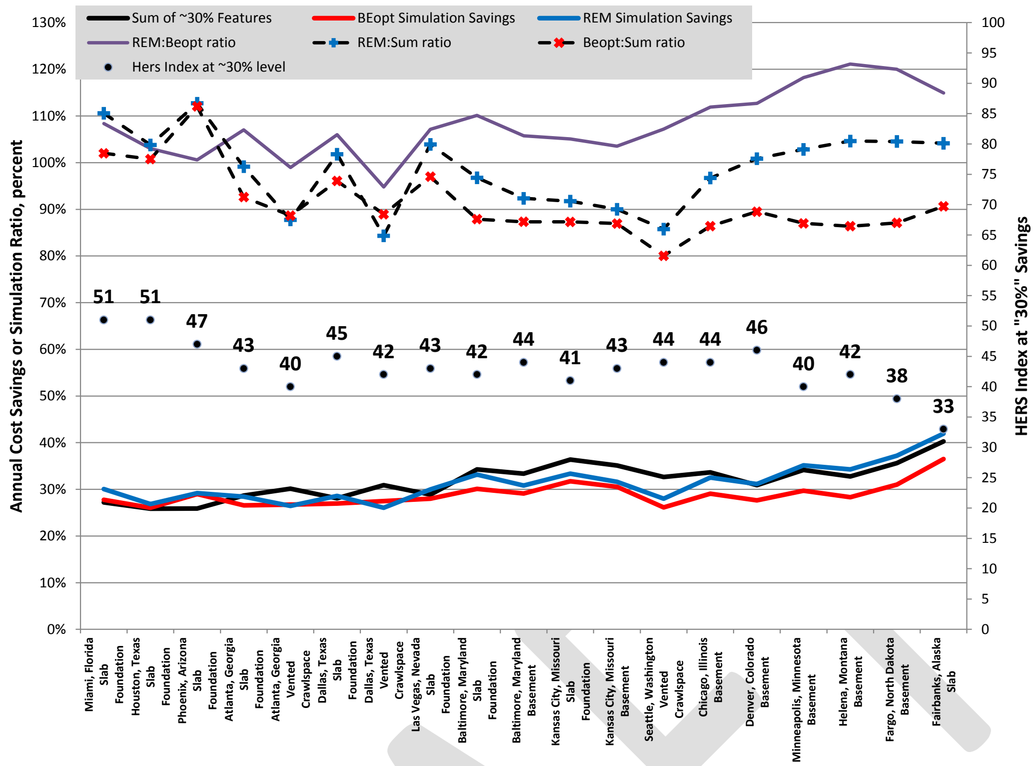

Figure 16. Graphical Summary of Comparative Simulation Results

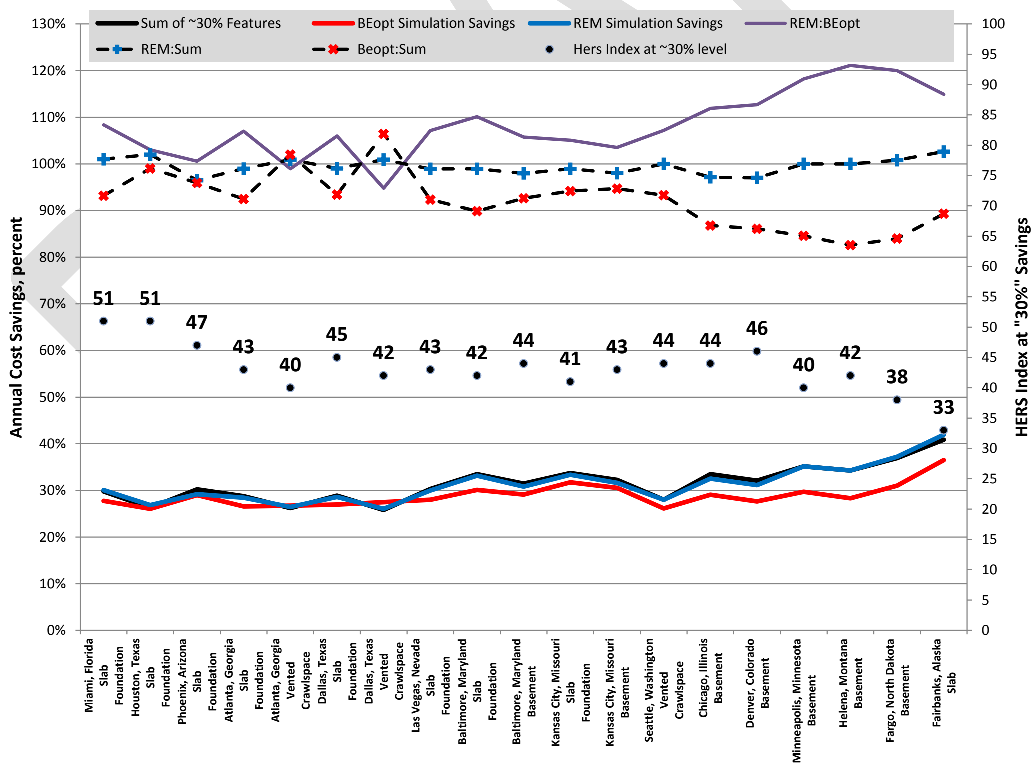

Figure 17. Graphical Summary of Simulation Results with Calibration Factor Applied

REM Calibrated Matrix of Simulation Parameters for the NGBS 2015 Chapter 7, Energy Efficiency, Prescriptive Path Points Analysis										
Proposed 2015 NGBS Section	Provision	Base Reference 2015 IECC	Climate Zone 1	Climate Zone 2	Climate Zone 3	Climate Zone 4	Climate Zone 5	Climate Zone 6	Climate Zone 7	Climate Zone 8
703.2.1	0 to < 5% UA improvement (Base)[1]	2015 IECC								
	5% to < 10% UA improvement	per location Use REMrate for levels	2	3	3	3	3	3	3	4
	10% to < 15% UA improvement		3	6	5	7	6	6	6	7
	15% to < 20% UA improvement		5	9	8	10	9	9	9	11
	20% to < 25% UA improvement		6	12	11	13	12	12	12	14
	25% to < 30% UA improvement		8	15	14	17	16	16	15	18
	30% to < 35% UA improvement		9	19	16	20	19	19	18	22
	>= 35% UA improvement		11	22	19	23	22	22	21	25
703.2.2	Insulation installation quality		0	0	0	0	0	0	0	0
703.2.3	Mass walls (< 6")	no mass	1	1	1	1	0	0	0	0
	Mass walls (≥ 6")	no mass	3	3	3	3	2	2	0	0
703.2.4	Radiant barrier	no RB	2	3	3	1	1	1	1	1
703.2.5	Envelope leakage, ACH50	5	0	0	0	0	0	0	0	0
		4	1	2	0	0	0	0	0	0
		3	2	4	0	0	0	0	0	0
		2	3	6	3	5	4	6	9	7
		1	4	7	5	8	7	10	16	12
703.2.6.2.1(a)	Fenestration level 1	2015 IECC Table 402.1.2	0	1	2	3	3	4	4	4
703.2.6.2.1(b)	Femestration level 2		2	3	4	4	4	5	5	5
703.2.6.2.1(c)	Femestration level 3		0	0	0	6	5	6	7	6
703.3.1	Combo heating system		4	4	4	4	4	4	4	4
703.3.2	Gas & Oil Furnace efficiency	≥ 85	0	1	2	3	3	5	5	6
		≥ 90	0	2	3	7	7	9	11	13
		≥ 92	0	2	4	8	8	11	13	15
		≥ 94	0	3	5	9	10	13	15	18
		≥ 96	0	3	5	10	11	15	17	20
		≥ 98	0	3	6	12	13	17	19	23
	Boiler efficiency	≥ 85	0	1	1	3	3	4	5	5
		≥ 90	0	2	3	6	6	8	9	11
		≥ 92	0	2	3	7	7	9	11	13
		≥ 94	0	2	4	8	8	11	13	15
		≥ 96	0	3	5	9	9	13	15	17
703.3.3	Heat Pump Heating	8.5 HSPF	0	1	1	3	2	2	2	1
		9.0 HSPF	0	2	5	5	7	11	16	8
		9.5 HSPF	0	3	8	8	11	20	30	16
		10 HSPF	0	5	11	10	16	28	45	23
	Gas Engine Heat Pump Heating	> 1.3 COP at 47F	0	0	0	0	0	0	0	0
703.3.4	Electric Air Conditioner and Heat Pump Cooling	≥ 14 SEER	0	4	1	0	0	0	0	0
		≥ 15 SEER	3	6	3	2	1	1	1	0
		≥ 17 SEER	10	9	7	4	3	3	2	0
		≥ 19 SEER	18	12	11	6	5	5	4	0
		≥ 21 SEER	25	15	14	8	7	7	6	0
	Gas Engine Heat Pump Cooling	> 1.2 COP at 95F	0	0	0	0	0	0	0	0
703.3.5	Water Source and cooled A/C	≥ 4 COP, 15 EER	0	0	0	0	0	0	0	0
703.3.6	Ground Source Heat Pump	14.1 EER, 3.3 COP	0	0	0	4	8	20		
		15 EER, 3.5 COP	0	0	0	9	12	25		
		16.2 EER, 3.6 COP	0	0	2	11	14	27		
		24 EER, 4.3 COP	23	30	23	29	29	43		
		28 EER, 4.8 COP	39	48	36	41	39	55		
703.3.7	E* ceiling fans	Standard	1	1	1	1	1	1	1	1
703.3.8	whole house ventilation fan		4	4	4	3	3	3	3	3
703.3.9	Submeter in multiunit		0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0
703.4.1	Ductless heating system	Standard duct install and location	0	2	4	7	8	9	8	17
703.4.2	Ductless cooling system		7	8	4	2	1	0	0	0
703.4.3	Duct installation (interior+)		7	10	8	9	9	9	9	17
703.4.4	Duct leakage 6% out	< 4cfm/100sf	2	2	2	2	2	2	2	2
703.5.1	Gas Water Heating	0.67 to < 0.80 EF	0	3	2	2	2	2	1	1
	(Use 40 Gallon for NGBS design)	≥ 0.80	0	4	3	2	2	2	2	1
	Large storage or Instaneous	≥ 0.90	0	6	5	4	3	4	3	2
	Large storage or Instaneous	≥ 0.95	0	7	6	4	4	4	4	2
	Electric Resistance Water	≥ 0.95	1	1	1	1	1	1	1	1
	Electric Instantaneous Water	≥ 0.97	1	2	2	2	2	2	2	2
	Heat Pump Water Heater	1.5 to < 2.0	16	7	5	3	2	1	0	0
		2.0 to < 2.2	21	10	7	4	2	1	1	0
		≥ 2.2	23	11	8	4	3	1	1	0
703.5.2	Desuperheater		22	17	10	7	6	4	2	2
703.5.3	Drainwater heat recovery		1	1	1	1	1	1	1	1
703.5.4	Indirect water heater		1	1	1	1	1	1	1	1
703.5.5	Solar Water Heating Gas or Electric Tank Backup (Savings is Average)	SEF 1.30	1	2	3	5	7	8	7	9
		SEF 1.51	1	2	4	7	10	11	11	12
		SEF 1.81	2	3	6	10	14	16	15	18
		SEF 2.31	4	5	9	16	21	23	22	26
		SEF 3.01	5	8	13	23	30	34	33	38
703.6.1	Hardwired lighting	100% HE	3	3	3	2	3	2	2	2
703.6.2	Recessed lighting		0	0	0	0	0	0	0	0
703.6.3	E* appliances - Refrigerator	Consistent with BA and RESNET Estimates	1	1	1	1	1	1	1	1
	Dishwasher		1	1	1	1	1	1	1	1
	Washing Machine		4	4	4	3	3	3	3	2
703.6.4	Induction cooktop		0	0	0	0	0	0	0	0
703.7.1	Sun-tempered design	standard reference house design	4	4	4	4	4	4	4	4
703.7.2	Window shading (active)		1	1	1	1	1	1	1	1
703.7.3	Passive cooling design		3	3	3	3	3	3	3	3
703.7.4	Passive heating (mass)		4	4	4	4	4	4	4	4

Figure 18. Summary Draft Points Table for Section 703 of the NGBS-2015

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