SUSTAINABLE GREEN BUILDING RATING SYSTEMS FOR ENERGY EFFICIENCY FOR NEW RESIDENTIAL BUILDINGS IN US

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Abstract: The Building Industry places a high demand on world's resources and there by impacting the environment. Currently Engineers are paying attention to sustainability based design concepts rather than traditional cost effective design concepts for buildings. In US there are about seventy five million residential buildings as opposed to mere five million commercial buildings. As such this paper addresses residential buildings as opposed to commercial buildings. In US there are several metrics to measure eco friendliness for homes. Three such systems are National Association of Home Builders Model Green Building (MGB) Guidelines, National Association of Home Builders Green Building Standard (ICC 700-2008) and United States Green Building Council's LEED (Leadership in Energy and Environmental Design). The Model green building guidelines address, seven criterions, lot design, resource/water/energy efficiency, indoor environmental quality, homeowner education, and global impact in determining sustainability. The ICC 700 uses very similar six criterions, lot design, resource/energy/water efficiencies, indoor environmental quality, operation, maintenance, and building owner education. The LEED recognizes sustainability with eight criterions of Innovative design process, location and linkage, sustainable sites, water efficiency, energy efficiency, materials selection , indoor environmental quality, and awareness and education. This paper discusses two rating systems used in US for eco friendly building design for **homes** with special emphasis on **effects of energy efficiency in rating values.** For energy efficiency requirements of International Energy Conservation Code is also addressed. Using a new home in California as an example the paper describes how to evaluate green building ratings for energy efficiency using three software tools for the MGB and GBS for homes in US.

Keywords: *Energy Efficiency, Green Building Ratings, National Association of Home Builders, Green Building Standard*

1. Introduction

The Building Industry places a high demand on world's resources and there by impacting the environment. According to the Environmental Protection Agency (EPA), the buildings in US accounts for about 40 % of annual energy use, 12 % of water consumption, and 88 % of electricity consumption [1]. Also buildings are known to be responsible for about 38 % of carbon dioxide emissions and 20-30 % of landfill deposits   in US [1]. Austin, Texas is considered the birthplace of green buildings in US having developed a green building program in '90s towards conserving energy [2]. Since economic benefits were readily apparent, other cities, states and the US Government realized the economic and environmental benefits of developing green building technology. Currently there are many programs in US which can rate a building project for sustainability and environmental impact [1]. Many of them have a rating tool with multiple thresholds for commercial and/or residential new and/or retrofit construction. Many of them also address the land, water, materials, and air quality and energy issues. These programs [1] are ASHRE, Green Global Design, ICC 700 NGBS, NAHB Model Green Home Building Guidelines, Green Globes online, DOE Energy Star Qualified Home, and USGBC LEED (for new construction, commercial interiors, existing buildings, homes, schools, retail, healthcare, and neighborhood development).

The basic principles of the following programs related to residential buildings were described in an earlier paper [3].

i)   Model Green Building (MGB) Guidelines by National Association of Home Builders(NAHB)
ii) National Green Building Standard (NGBS) by National Association of Home Builders(NAHB)
iii) Leadership in Energy and Environmental Design (LEED) Programs by The United States Green Building Council (USGBC)

The current paper describes **the analysis of Energy Efficiency on the green building rating systems of MGB Guidelines and NGBS using an example building.** Both of these require Energy efficiency compliance with International Energy Conservation Code (IECC) [4] or State approved similar standard in addition to other requirements. For this study IECC 2009 is used.

2.   The Example Building

The example building is a new two story single residence with attached two car garage. The project site is situated on a hill side in Monterey Park, a suburban of Los Angeles, California. The first floor living area is 1,638 square feet which includes the living room, family room, dining room, kitchen, and bathroom. The second floor living area is 1,358 square feet which includes three bedrooms and two bathrooms. The total living area is 2,996 square feet on a 7,504 square feet lot. The square footage of the house is above the typical average for this area.

3.   International Energy Conservation Code (IECC®) 2009 Compliance Study

The IECC® deals with new construction, remodeling, window replacement etc. The code addresses both residential and commercial buildings. The code ensures energy efficient building envelopes and energy efficiency of elements of buildings that are not part of building envelope. The Residential portion of the Code deals with buildings that are three stories or less. Currently the State of California requires the buildings to be in compliance with IECC. For checking the IECC compliance the code refers to tools such as ResCheck TM [5] a software tool for detailed plan analysis of the building for energy efficiency.

REScheck considers the energy ratings of windows, doors, walls, ceiling, floors etc. REScheck examines the effect of different levels of insulation (R value), window U-values and solar heat gain coefficient (SHGC) factors, and space conditioning equipment efficiencies to identify a cost-effective system. R value is an indication of thermal resistance, higher values indicating higher thermal resistance, thus energy savings. The U value measures the conduction of heat and is the reciprocal of the R value. These R and U values are set by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers. The SHGC factor is a measure of effectiveness of window glazing in minimizing solar heat. SHGC is used by the National Fenestration Rating Council (NFRC). REScheck program calculates an overall UA (U*A) of a building by first multiplying U factor of each element (such as a window) by its area and then summing U*A for all the components in the building. The program then compares this value against code given maximum values. If the total heat loss (represented as a UA) of your building does not exceed the total heat loss allowed for the same building per the code, then the building confirms to the IECC code. A partial view of the REScheck results for the example building is shown in Figures, 1, 2 and 3. After running REScheck software the example residence is 24% above IECC 2009 requirements and hence achieves compliance.

Compliance: Passes using UA trade-off

Compliance: Maximum UA: **776**   Your UA: **590**   Maximum SHGC: **0.30**   Your SHGC: **0.30**

Assembly	Gross Area or Perimeter	Cavity R-Value	Cont. R-Value	Glazing or Door U-Factor	UA
Ceiling: Flat or Scissor Truss	2996	22.5	22.5		66
Wall - 1st Floor: Wood Frame, 16in. o.c.	369	10.0	10.0		18
Orientation: Front					
Window: Vinyl Frame, Double Pane	45			0.300	14
SHGC: 0.30 Orientation: Front					
Wall - 1st Floor: Wood Frame, 16in. o.c.	428	10.0	10.0		19
Orientation: Back					
Window: Vinyl Frame, Double Pane	54			0.300	16
SHGC: 0.30 Orientation: Back					
Door: Solid	40			0.500	20
Orientation: Back					
Wall - 1st Floor: Wood Frame, 16in. o.c.	504	10.0	10.0		22
Orientation: Right Side					
Window: Vinyl Frame, Double Pane	72			0.300	22
SHGC: 0.30 Orientation: Right Side					
	40			0.500	20

Figure 1: Partial View of REScheck Software Analysis for Energy Efficiency

Figure 2: Partial View of Recheck Energy Efficiency Certification

Figure 3: View of REScheck Energy Efficiency certificate

4. Model Green Building (MGB) Guidelines Compliance Study

First published in 2005, National Association of Home Builders (NAHB) model green building guidelines [6] were intended to be a baseline so that members could develop local green building programs. The MGB guidelines were written only for single family new construction. The guidelines consider seven factors in Table 1, to determine three levels of ratings Bronze, Silver, and Gold.

For each category of seven, a score is assigned based on satisfying several requirements. For the above seven categories, there is a minimum number of points required for the three levels of ratings mentioned above. This is to ensure that the all aspects of green building principles are addressed to some extent. In addition there is a minimum total point score required for each level of achievement which is depicted in Table 1.

The National Association of Home Builders has made available to public a user friendly online scoring tool at http://www.nahbgreen.org/ScoringTool/ free of charge. A partial view of the MGB online scoring tool is shown in Figure 4.

Table 1: Threshold Point Ratings for Green Buildings per Model Building Guidelines
Applicable for Single Family Homes

Threshold Point Ratings for Green Buildings			
Green Building Categories	Performance Point Levels		
	BRONZE	SILVER	GOLD
1. Lot Design, Preparation, and Development	8	10	12
2. Resource Efficiency	44	60	77
3. **Energy Efficiency**	**37**	**62**	**100**
4. Water Efficiency	6	13	19
5. Indoor Environmental Quality	32	54	72
6. Operation, Maintenance, and Home Owner Education	7	7	9
7. Global Impact	3	5	6
8. Additional Points from any category	100	100	100
Total Points	237	311	395

Source: Per information at http://www.nahbgreen.org/ScoringTool/

The Energy Efficiency ratings are detailed in Chapter 3 of the guidelines. The tool queries many aspects of the building including quality of duck system work, exhaust system of bathrooms, water heater, insulations, energy star labeled appliances, energy star lighting packages, and compliance with International Energy Conservation Code (IECC) [4].

As seen in the Figure 5, the section 3.1.1 of the MGB tool queries if the building is equivalent to IECC or local energy code. As depicted similar compliance checks are performed as part of MGB guideline checks.
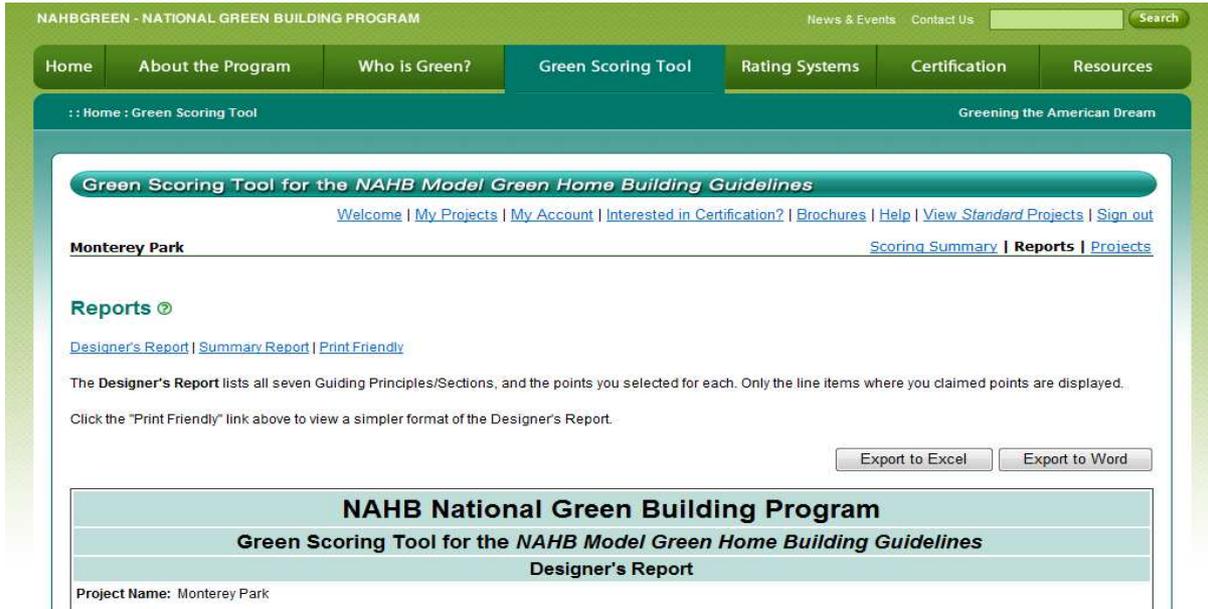
Figure 4: Partial View of Green Building Scoring Tool per MGB Guidelines
(Per information at http://www.nahbgreen.org/ScoringTool/)

Figure 5: Partial View of Green Building Scoring Tool per MGB Guidelines
(Per information at http://www.nahbgreen.org/ScoringTool/)

After analysis of many other factors such as insulation of hot water lines, heat traps between hot and cold water lines, use of ENERGY STAR® advanced lighting packages, and ENERGY STAR® appliances, and allocating points the tool come up with a total score of 75 points for Energy Efficiency of the building. Based on total points claimed for Section 3 (Energy Efficiency) the building qualifies as a Silver level rating (minimum 62 points) for Energy efficiency of the building.

Total Points Claimed in Section 3: Energy Efficiency		Bronze	Silver	Gold
		Required Points	37	62	100
	75	Additional Points	96	71	33

Figure 6: View of Total Score for Energy Efficiency per MGB Guideline Tool

5. National Green Building Standard (NGBS ICC 700-2008) Compliance Study

This standard was developed by expanding the Model Building guidelines to include single family/multifamily homes, residential remodeling, and site development. The American National Standards Institute (ANSI) approved this standard as International Code Council (ICC) 700-2008 [4] in 2009. Thus this becomes a consensus developed option. The standard considers the six factors in Table 2 to come up with four levels of ratings **Bronze, Silver, Gold, and Emerald**.

Similar to the MGB guidelines there is a minimum number of points required in each of the above categories for each level of ratings. As shown on the NAHB web site (www.nahbgreen.org/Guidelines/ansistandard.aspx), the threshold values are as follows

Table 2: Threshold Point Ratings for Green Buildings per National Green Building Standard (ICC 700-2008) applicable to Single and Multi Family Homes
Source: http://www.nahbgreen.org/Guidelines/ansistandard.aspx

Threshold Point Ratings for Green Buildings						
Green Building Categories			**Performance Point Levels (1) (2)**			
			BRONZE	**SILVER**	**GOLD**	**EMERALD**
1.	Chapter 5	Lot Design, Preparation, and Development	39	66	93	119
2.	Chapter 6	Resource Efficiency	45	79	113	146
3.	**Chapter 7**	**Energy Efficiency**	**30**	**60**	**100**	**120**
4.	Chapter 8	Water Efficiency	14	26	41	60
5.	Chapter 9	Indoor Environmental Quality	36	65	100	140
6.	Chapter 10	Operation, Maintenance, and Building Owner Education	8	10	11	12
7.		Additional Points from any category	50	100	100	100
Total Points			222	406	558	697
(1) In addition to the threshold number of points in each category, all mandatory provisions of each category shall be implemented.						
(2) For dwelling units greater than 4,000 square feet (372 square meters), the number of points in Category 7 (Additional Points from any category) shall be increased in accordance with Section 601.1. The "Total Points" shall be increased by the same number of points.						

The National Association of Home Builders web site also has a user friendly online **scoring tool at** http://www.nahbgreen.org/ScoringTool/ free of charge for National Green Building Standard (ICC 700-2008) based scoring for green homes. A partial view of the scoring tool is shown in Figure7. As can be seen the standard has some mandatory practices clauses (section 701), the example building complied.

CHAPTER 7 - Energy Efficiency

Section 701 -Minimum Energy Efficiency Requirements

Practice 701.3 Mandatory practices: Third-party Review

A review of the design has been conducted by a third party to confirm that the intent of the Standard with respect to energy provisions has been met.

Conditions met	Points Claimed: 0

Documentation Required - None.

Practice 701.4.1 Mandatory practices: HVAC systems

Space heating/cooling sized per ACCA Manual J.

Conditions met	Points Claimed: 0

Documentation Required - Provide software output report using ACCA Manual J or equivalent with recommended HVAC equipment sizes.

Figure 7: Partial View of Green Building Scoring Tool per ICC 700-2008.
(http://www.nahbgreen.org/Guidelines/ansistandard.aspx)

The standard also requires through the Performance path (Sec. 702) that Energy Efficiency performance be more than at least 15% of IECC minimum requirements. By selecting the performance path the standard allows flexibility in that some part of the building may be less efficient than expected of IECC as long as the overall building meets the required performance. The performance path allows the designers to consider variety of factors such as roof reflectivity, shading devices etc. Since our IECC 2009 analysis through REScheck software has a performance of 24 % more than the IECC baseline, this building receives 30 points (minimum required 15% more than IECC performance.) for this section as shown in Figure 8.

Section 702 -Performance Path

Practice 702.2 Performance Path

Points from the Performance Path (section 702) shall not be combined with points from the Prescriptive Path (section 703).

A documented analysis shows performance in excess of IECC by at least 15%, 30%, 50%, or 60%.

15%	Points Claimed: 30

Figure 7: Partial View of Green Building Scoring Tool per ICC 700-2008.
(http://www.nahbgreen.org/Guidelines/ansistandard.aspx)

With all the points accounted for in Chapter 7 (Energy Efficiency) of the standard the building received 73 points and qualified to be Silver (minimum 60 points) rating as shown in Figure 8.

Figure 8: View of Total Score for Energy Efficiency per ICC 700-2008 Tool (http://www.nahbgreen.org/Guidelines/ansistandard.aspx)

6. Discussion

The paper surveys two popular methods for rating green residential buildings in the United States. The two methods are very similar. As such the MGB guideline tool is planned to be discontinues beginning 2011 and the Green building standard tool to continue. The builders and designers of homes may find the user friendly free online tool based on ICC-700 and REScheck useful. The ICC 700-2009 is an accepted standard by the American Standard Institute (ANSI) which makes it a consensus developed option.

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