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Home Energy Ratings and Building Performance

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ABSTRACT

This paper provides an overview of the Home Energy Rating System (HERS). A short summary of the origination and history of the HERS system will lead to a more detailed description of the inspection and testing protocol.

The HERS rating provides an accepted method to determine home efficiency based on standards developed and overseen by the Residential Energy Services Network (RESNET), a not-for-profit corporation.

The paper will discuss the effect of various building systems and effects of local climate as they affect the rating score of a proposed or completed structure. The rating is used to determine the most cost effective mechanical systems, building envelope design including window and door types, effect of various roofing materials and radiant barriers.

The paper will conclude by comparing specifics of an actual report to the construction characteristics of a home as they relate to the HERS Rating and the result.

INTRODUCTION

A great deal of work in the 1990's to determine and reduce the energy used in residences was done by the Department of Energy, national laboratories and the mortgage industry. The problem was that different construction and efficiency requirements are used in the many different climates of the United States. A solution was needed to allow a scoring system that could be used to compare houses in these different regions equally. Residential energy codes were being developed at the same time resulting in further need for standardization.

In 1995, RESNET was created by the National Association of State Energy Officers (NASEO) and Energy Rated Homes of America. RESNET is a member of the National Mortgage Bankers Association and is guided by several committees and an elected Board of Directors.

The Residential Energy Services Network, RESNET provides standards for accreditation of raters, providers and trainers, ethics and protocols for inspection, testing and software analysis. The ratings are used to assist builders to provide a cost effective building design, evaluation to Energy Star standards and the acceptability for Energy Efficient Mortgages. An important use of the rating system is consumer education and providing feedback to architects and homeowners that the construction meets the design specifications and quality standards expected.

A home energy rating is a standard measurement of the home's energy efficiency, and allows a home buyer to compare the energy costs for the homes being considered. For existing homes, the evaluation will measure the current energy efficiency and allow the rater to suggest cost effective recommendations for improvement. Home energy rating inspections are conducted on-site by residential energy efficiency professional.

A RESNET rating provides a relative energy use index called the HERS index. An index of 100 represents the energy use of the "American Standard Building" where an index of zero indicates a zero energy building. An index of 85 or less is required to achieve ENERGY STAR status in climate zones 1 – 5.

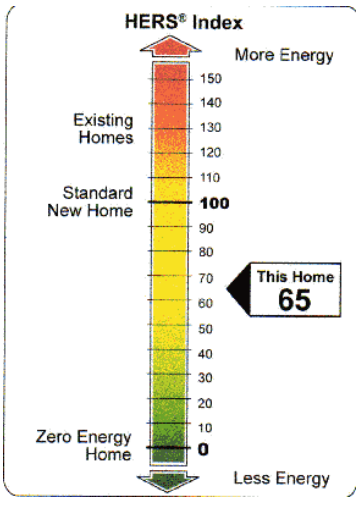

Figure 1. HERS Index

COMPONENTS OF A HERS RATING

The HERS evaluation includes the effect of various heat transfer mechanisms on the building envelope, optimizing the heating, cooling and ventilation and hot water systems, efficiency of various building systems, effects of local climate and utility rates and determining potential building problems. The rating is used to determine the following; most cost effective mechanical systems, the building envelope design including insulation type and installed thickness, type of windows and doors, the effect of various roofing materials and radiant barriers.

THE HERS RATING PROCESS

Plan Review

Plans can be reviewed prior to construction to determine potential design strategies. Dimensions must be accurately recorded to determine areas and volumes of the structure. After construction, as built dimensions must be used for all calculations as these may deviate from the construction drawings.

Building Inspection and Evaluation

Perhaps the greatest use of the rating system is to provide feedback during construction to evaluate the design targets. Careful inspections can find deficiencies in insulation levels, envelope sealing procedures and incorrect installation of HVAC systems.

Blower door test (air infiltration)

The blower door test quantifies the tightness of the building envelope by measuring air infiltration. A calibrated fan is used to depressurize the structure to a 50 Pa pressure difference with respect to the outside. The amount of air flowing out of the house is equal to the amount of air leaking into the house.

Figure 2. Blower Door

Duct blaster (duct leakage)

The duct blaster test provides an evaluation of the tightness of the duct system. Duct design, duct material, duct installation and duct leakage all affect the ability or the duct work to deliver sufficient air to satisfy the cooling and heating loads. The duct leakage is determined by attaching a fan (Duct Blaster) to the return air grill and sealing off the supply registers. By pressurizing the ducts, the leakage can be determined by measuring the fan pressure required to overcome any leakage to the outside.

Figure 3. Duct Blaster

Building Envelope

The inspection and testing of the home is based on the integrity of the building envelope. The building envelope is an air and/or thermal boundary between the conditioned (inside) space and the unconditioned (outside) space. The walls, floor, ceiling and roof are designed to maintain a comfortable environment inside the building envelope for the homes occupants.

Current building technologies allow very efficient building envelopes which are a starting point for the latest designs of zero energy homes (ZEH). These homes feature very low or zero energy consumption from the utilities (gas and electric).

Reports

The home energy rater is responsible for inspecting and testing the home's minimum rated features that include information about the foundation, walls, doors and windows, roof and ceiling, air infiltration, heating and cooling equipment, the duct system, duct leakage and water heating (standard water heater and solar water heating). The information is input to a software program, approved by RESNET, which generates a complete energy efficiency review. It must be understood that this is a snapshot of the rating on the home at the time of the inspection. Any changes afterward can affect the results. It is particularly important to recognize if the rating is based on the construction drawings or is performed prior to the completion of the job.

A "reference home" is included in the calculations. The reference home is built to the minimum energy code standards for the region of the country and uses default values for air infiltration and distribution (duct) system efficiencies. This provides a "reference" energy usage for comparison to the rated homes estimate of energy consumption.

Home Efficiency and Comfort

With today's energy prices on everyone's mind, energy efficiency is no longer just a buzz word. Real dollars can be saved with a properly built and maintained home. Even older homes can be improved dramatically. The place to start is with a Home Energy Rating. This tool provides a priority of steps that, when completed, will increase the efficiency of any house. The results of the rating will specify exactly which improvements will provide the biggest bang for the buck. Typically, these revolve around insulation, sealing air leaks, proper sizing of the HVAC equipment and repairing leaky ducts.

The building envelope; walls, windows, doors, foundation and the ceiling/roof are all sources of heat loss in the winter and heat gain in the summer. Heat loads inside the house, from appliances, lighting and people also contribute to the heat load in the summer. We spend a large percentage of the construction cost to add or remove heat from the home. In addition to this, in many regions of the country the removal of moisture is essential to a comfortable and healthy home.

In hot and humid climates, moisture removal is as important as cooling the conditioned spaces. Efficient design and construction of a home will prevent most moisture from entering the envelope and a properly sized and sealed cooling system will remove moisture inside generated by cooking, showers and people.

Comfort levels in the home are specific to the occupants and usually different for each of them. People are generally comfortable at a relative humidity of between 40 – 50%. Comfort is a function of surface temperatures, the air flow over your skin, the air temperature and the humidity level. One of the most important parts in the building specification is the AC equipment and installation requirements and the duct design to achieve efficient cooling and humidity control.

CLIMATE ZONES IN THE UNITED STATES

There are seven (7) climate zones in the United States. These include the following:

- Hot – Dry Climate zone (2 & 3)
- Mixed – Dry Climate Zone (4)
- Hot – Humid Climate Zone (1, 2 & 3)
- Mixed – Humid Climate Zone (3 & 4)
- Marine Climate Zone (3 & 4)
- Cold Climate Zone (5 & 6)
- Very Cold Climate Zone (7)

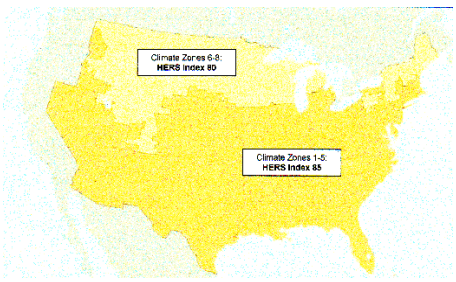

Figure 4. Climate Zones

These climate zones vary by rain fall amounts and temperature variations including minimum and maximum annual temperatures. Each of these requires a different approach to the energy efficient design. The HERS Rating provides a proven approach to quantifying the best design for your area.

ENERGY CODE COMPLIANCE

The International Code Council publishes the International Energy Conservation Code for the different climate zones of the country. These codes set forth basic requirements for construction of the following:

- Building Envelope
- Insulation
- Windows
- Mechanical System
- Recessed light fixtures

The International Energy Conservation Code provides three paths for demonstrating code compliance. One path is to follow a specific list of building components for the climate zone. This is referred to as the "prescriptive path" Substitutions are not allowed. Another path is to install components that use less energy than the code specifies. This is called the "component path". The third path is to perform energy analysis using software modeling, looking at energy consumption over the entire year. If the home uses less energy than the home built to the minimum code standards, it is deemed compliant.

A HERS REPORT

On December 18, 2008, the authors' house was inspected and tested resulting in a HERS Rating of 52. A copy of the report is found in Appendix 1. The HERS Rating was calculated using REM/Rate - Residential Energy Analysis and Rating Software v12.41.

The data entered into the software included the following components:

- Building information (Area (ft^2) & Volume (ft^3)
- Foundation
- Above grade wall
- Window information and orientation
- Door information and orientation
- Roof, Ceiling & Attic information
- Skylight
- Mechanical Equipment (HVAC and DHW)
- Duct Information
- Lights & appliances
- Solar Hot water system
- Photovoltaic System

The software generates a fuel summary, lights and appliance summary and house performance summary.
The summaries compare the rated house to the reference house and provide a percent difference between the two.

Fuel Summary

Electric and propane annual cost is 44% less than the reference house.

The annual end use cost for heating, cooling, water heating, lights and appliances and the photovoltaic system was 41% less than the reference house.

Lights and Appliance Summary

Electric consumption (kWh/yr) was 19% less than the reference home.

Annual energy cost ($/yr) was 19% less than the reference house.

Performance Summary

Annual consumption (MMBtu/yr) was 44% less than the reference home.

Annual energy cost ($/yr) was 41% less than the reference house.

Two major issues were found with the testing. 1). The air infiltration exceeded minimum requirements for ENERGY STAR. The infiltration was tracked to excessive leakage around

indirect lighting in the living room and around the bathroom vents.
2). The duct leakage exceeded minimum requirements for ENERGY STAR. The leakage was found around three supply register boots and a hole in the return plenum.

These issues show clearly that a low HERS Rating does not insure an Energy Star certification. There are minimum requirements for Energy Star that can be found on the Energy Star website. I the case of the authors home, corrections have been made to improve the issues listed above. The home has not yet been re-rated.

The resulting HERS Rating for the author's home was a 52.

CONCLUSION

A HERS report provides feedback on the design and construction of a tested home compared to a reference home. As seen in the author's home, problems can be identified so repairs or other changes can be made to correct these issues. The HERS Rating inspection and testing offers an excellent method of predicting building performance from construction drawings and quantifying building performance after completion of construction.

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VITA

John C. Gardner graduated from Texas A&I University with a BSEE and is a Professional Engineer in the State of Texas. He is a member of the American Solar Energy Society, American Wind Energy Association, the Houston Renewable Energy Group and a board member of the Texas Solar Energy Society. John has made several presentations on renewable energy including Speaker at the 2007 Boineers Conference in Houston**.** John's energy efficient home was featured on the 2008 ASES, Houston Renewable Energy Group Chapter Solar Tour and has been the subject of articles in the Wall Street Journal and the local paper. John is employed by Standard Renewable Energy as a Sales Engineer. He is a senior member of IEEE and a member of the Industrial Applications Society. He has authored five IEEE papers.

Appendix 1 - HERS Report

ENERGY STAR

ENERGY STAR HOME VERIFICATION SUMMARY

Date:	July 02, 2008	Rating No.:	56775-102
Building Name:	Gardner Residence	Rating Org.:	Beacon Energy Solutions
Owner's Name:	John and Karen Gardner	Phone No.:	713-513-6180
Property:	31115 Hegar Rd.	Rater's Name:	Tony W. DeRamus
Address:	Hockley, TX 77447	Rater's No.:	1998-103-BER-507
Builder's Name:			
Weather Site:	Houston, TX	Rating Type:	Confirmed Rating
File Name:	31115 Hegar Rd Building File.blg	Rating Date:	12-18-2007

Building Information

Conditioned Area (sq ft):	2125	Housing Type:	Single-family detached
Conditioned Volume (cubic ft):	19720	Foundation Type:	Slab
Insulated Shell Area (sq ft):	5794	HERS Index:	52 *****+
Number of Bedrooms:	2		

Building Shell

Ceiling w/Attic:	R-30 Batt, Attic U=0.036, with Barrier	Window/Wall Ratio:	0.14
Vaulted Ceiling:	None	Window Type:	.36 - .29
Above Grade Walls:	R-15 U=0.079	Window U-Value:	0.360
Found. Walls (Cond):	None	Window SHGC:	0.290
Found. Walls (Uncond):	None	Infiltration:	Htg: 1847 Clg: 1847 CFM50
Frame Floors:	None	Measured Duct Leakage:	273.00 CFM25
Slab Floors:	Uninsulated U=0.285	Leakage to Outside:	273.00 CFM

Mechanical Systems

Heating:	Fuel-fired air distribution, 80.0 kBtuh, 80.0 AFUE.
Water Heating:	Conventional, Prop, 0.59 EF, R-5 wrap.
Cooling:	Air conditioner, 48.0 kBtuh, 14.0 SEER.
Programmable Thermostat:	Heat=Yes; Cool=Yes

Note: Where feature level varies in home, the dominant value is shown.

This home DOES NOT MEET the EPA's requirements for an ENERGY STAR Home.

REM/Rate - Residential Energy Analysis and Rating Software v12.41