Unlocking Energy Efficiency in U.S. Homes

A Framework for Change

Structured Adoption of a Standard Measurement System for Home Energy Ratings and Implementation of a Performance Rating

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ASHRAE POLICY RESEARCH INTERN

Table of Contents

DID YOU KNOW?

"The average U.S. home has about two TVs, a VCR, and a DVD player that consume energy in the "off" mode to keep display clocks running, and memory chips and remote controls working. These "energy leaks" account for 5% of total U.S. electricity use."

-San Diego Environmental Services Department (33).

About the WISE Program:

The Washington Internships for Students of Engineering (WISE) program works to bridge the gap between technical professionals and policy makers by introducing engineering students to Washington, D.C.. The students are sponsored by an engineering society based upon a competitive selection process and tasked with conducting policy research around a technical topic of their choosing. The interns are given the opportunity to meet with influential figures in Congress, committees, industry, and non-governmental organizations in order to thoroughly gain an understanding of the policy making process, and to research their selected topics. The product of the student's work is a policy paper which is published in the Journal of Engineering and Public Policy.

About ASHRAE:

ASHRAE, founded in 1894, is a global society advancing human well-being through sustainable technology for the built environment. The Society, and its more than 50,000 members worldwide, focus on building systems, energy efficiency, indoor air quality, refrigeration and sustainability. Through research, standards writing, publishing, certification and continuing education, ASHRAE shapes tomorrow's built environment today.

About the Author:

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Glossary:

ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
bEQ	Building Energy Quotient
DOE	U.S. Department of Energy
EEM	Energy Efficiency Mortgage
EISA	Energy Independence and Security Act of 2007
EPA	U.S. Environmental Protection Agency
ESPM	Energy Star Portfolio Manager
GSA	U.S. General Services Administration
HEPR	Home Energy Performance Rating
HES	Home Energy Score
HERS	Home Energy Rating System
HUD	U.S. Housing and Urban Development
ICC	International Code Council
IEA	Internal Energy Agency
IECC	International Energy Conservation Codes
LEED	Leadership in Energy and Environmental Design
MHCSS	Manufactured Home Construction and Safety Standard
PE	Professional Engineer
PNNL	Pacific Northwest National Laboratory
RESNET	Residential Energy Service Network
SAVE	Sensible Accounting to Value Energy
USGBC	U.S. Green Building Council

home performance. Consequently, the rating would hold validity and offer less confusion in the market. This would create a systematic change in behavioral energy use and ultimately reduce residential energy consumption. When considering home energy use, behavior is an area that can have significant benefits for homeowners if improved. ASHRAE member Larry J. Brackney, Ph.D., stated, "A full 30% of a building's energy performance is related to occupant behavior and simply can't be ignored as we envision a path to a better built environment". (3)

Energy use due to the behavior of home occupants is often wasteful because of energy misconceptions that partially stem from a lack of understanding. Studies show that people underestimate how much power is used by appliances when they are powered off and still plugged into an outlet. To help promote understanding, energy use in homes needs to be more transparent to non-experts. Through a better understanding, home occupants can start to improve how they use energy. Educating homeowners is possible through emerging technologies that allow occupants to monitor and control the electrical consumption of all devices in their homes. (4)

The lack of state code uniformity also contributes to the complexity of quantifying home energy ratings. For example, only seventeen state governments have adopted the 2006 International Energy Conservation Code (IECC)[4] as a state code. Many states enforce less stringent energy codes, while other states, such as California and Oregon, enforce more stringent energy codes. The U.S. Department of Energy found states with a statewide energy code have a higher statewide jurisdictional adoption rate on average than states without. (5) As a result, it is very important that each state enforces the proposed standard measurement system for home energy ratings. To do this, strong collaboration between the private and public sector is needed. Rating programs, technical organizations, and federal agencies will need to work together to synthesize a measurement system and ensure an effective implementation strategy.

[4] The IECC 2006 establishes minimum regulations for energy efficient buildings using prescriptive and performance-related provisions.

- Metric: A quantitative measurement tool used when conducting a home energy rating.

An energy index offers homeowners a reliable tool to rate home energy ratings against each other. The ability to analyze different ratings or to assess progress towards a national rating will depend on establishing energy efficiency metrics. The creation and adoption of a standard measurement system is necessary as a preliminary step in creating a national rating index.

1.2 Home Energy Metrics, Ratings, and Certifications

A home energy rating (HER) is a score that is based on a comprehensive evaluation of the efficiency of the entire home. When a home receives a HER, the homeowner typically receives a written report that includes a numeric score or "rating" of the home, plus recommendations for improvements that will reduce energy bills and make the home more comfortable. Then, if a home is found to meet or exceed a specific rating, a home energy certification can be issued. An important note to make is that certifications can differ greatly depending on which program the rating is from, as the ratings may be calculated using different metrics. This means a home satisfying the qualifications for one program's certification level may fall short or exceed the same level of certification if rated by a different program. For example, a home rated by the National Association of Home Builders (NAHB) will be based on the 2012 ICC 700[7] National Green Building Standard. Rather, a home being rated using U.S. Green Building Council's (USGBC) Leadership in Energy Efficiency Design for Homes (LEED H) will be based on the EPA's Energy Star 2006[8] requirements. This can result in the same home receiving two different energy ratings and raises the question as to which is "better" or "correct". Only through using a standard measurement system, similar to the one the HERS Index uses, can there be a shared benchmark for each state's residential building standards, model codes, codes, and voluntary programs to be based on. A non-exhaustive summary of home energy rating certification programs can be found in Appendix A.

1.3 Energy Efficiency vs. Energy Consumption

Home energy efficiency is different than home energy consumption. Energy efficiency depends upon the physical features of the home and all the equipment it contains. Energy consumption is the actual amount of energy used and is impacted by equipment efficiency and the energy use behavior of home occupants. This is an important difference because installing energy efficient appliances does not guarantee lower energy consumption. If an "efficient" light bulb replaces an "inefficient" light bulb, and is left on more often because of its efficiency rating, the total energy used over time may be greater. This phenomenon is referred to as

[7] The ICC 700 is a National Green Building Standard that references the 2009 version of the International Energy Conservation Code (IECC).

[8] EPA's Energy Star 2006 requires that certified homes are at least 15% more efficient than those built to the 2009 International Energy Conservation Code (IECC).

Jevons Paradox and has been demonstrated by past events.[9] Other wasteful habits, unusual or extreme weather, or malfunctioning equipment can also drive up energy bills, even in the most energy-efficient house in the neighborhood.

1.4 Home Energy Misconceptions

People agree that home energy efficiency makes sense – the goal of lower bills is compelling, but myths and misconceptions are still a factor. As an example, in a survey done by Ipsos Social Research Institute in January 2014, 60% of people think that if an electric appliance is switched off, it doesn't use any electricity even if it is still plugged into the wall. (2) In the same survey, more than 60% of people said they would be more energy efficient if someone told them how to be. In turn, the goal to save energy and money has hit home; people just need to know how. This can be resolved by educating home occupants about a home's energy use. Home energy data needs to be more transparent to non-experts, thus making its value more concrete in the marketplace (8). A practical way to accomplish this is through a metering system that homeowners can understand and interact with. The advantages would include lower energy costs and encourage energy efficient upgrades for sellers aiming to attract the market. In section 3, the metering system is discussed more fully.

> A study of energy-efficient homes in The Appraisal Journal showed that a $1 reduction in annual energy bills resulted in more than a $10 increase in resale value.

1.5 Too Many Options: A Problem That Can Paralyze

The number of different home ratings used by energy programs can be difficult for homeowners to keep up with. National governments, local governments, even private organizations are all coming up with their own programs, each with their own set of colored graphs, metrics, and political supporters. The complexity is arguably causing confusion and divergence from a much needed nationally adopted measurement system. Conversely, it has long been the common wisdom in our country that there is no such thing as too many choices. As psychologists and economists study the issue, they are concluding that an overload of options may actually paralyze people or push them into decisions that are against their own best interest. For example, most of us know that it's a wise decision to save in a 401(K), but studies have shown that if more fund options are offered, fewer people participate. And the highest participation rates are among those employees who are automatically enrolled in their company's 401(k)'s unless they actively choose not to be. (9) Likewise, rather than contributing to a national metric, organizations have instead devised separate metrics. This raises the

[9] The first fuel-economy regulations for U.S. cars were followed by a long-term rise in motor fuel consumption, as well as an increase in horsepower, car ownership and a 100% increase in vehicle miles traveled since 1980.

question whether the number of different metrics has hindered participation and/or prevented the public from gaining a truly comprehensive understanding of the energy ratings their homes are receiving. In Appendix B, Table 3 compares two federal rating programs; the DOE's home energy score and the EPA's home energy rating score. Both HERS and HES are federal programs established through government agencies but their differences are surprising. This proves how even between federal agencies, there is confliction about what a home rating structure should be.

1.6 Building Energy Codes and Voluntary Programs

Both governmental and non-governmental organizations have agreed that buildings, as the largest contributor to greenhouse gases, need to be energy efficient. (10) To make this happen, changes are being made through building codes and voluntary programs. While codes are mandatory regulations, voluntary programs are followed by choice in addition to code. Voluntary programs encourage home owners and builders to exceed minimum code requirements in order to improve the energy performance of their homes. "The average size of homes built in 2013 hit 2,600 square feet, an all-time high that surpassed even the housing bubble years when homes averaged around 2,400 square feet, according to the U.S. Census Bureau" (11). To deal with the growing overall residential energy consumption in the U.S., increasingly stringent home building codes and voluntary programs, like Energy Star for homes and LEED H, are continuing to develop.

based on the aggregate count of all votes cast. (13) Congress can then vote on whether to federally mandate that homes meet minimum code requirements.

2.1 Actions Taken by the Executive Branch

Can turning your lights off before you leave the house really make an impact? The answer is yes, as shown by recent reports from the United Nation's Intergovernmental Panel on Climate Change (14) and the White House (15).“President Obama is pursuing a wide range of initiatives that reduce greenhouse gas emissions through clean energy technologies and policies”, such as Green Button (16). The government’s attempts to reduce the nation’s energy use has been impactful but true change will take cooperation from all industries in order to synthesize an effective solution.

Every 5 years, the U.S. General Services Administration (GSA) is required to evaluate green building cortication systems to formally identify a system to be used across the federal government. In March 2012, Pacific Northwest National Laboratory (PNNL) was contracted to do this and recounted their findings for the GSA in a report called the Green Building Certification System Review. During the report, screening criteria was used to identify which systems met the minimum expectations of a green building certification system with respect to the Energy Independence and Security Act of 2007 (EISA)[11] criteria (17).

The screening criteria were:

- Systems must employ whole building evaluation, addressing key sustainable design and operations metrics;
- Systems must be available in the U.S. market;
- Systems must have third party certification.

Three certification systems passed the screening criteria: Green Building Initiative’s Green Globes, USGBC’s Leadership in Energy and Environmental Design and the International Living Building Institute’s Living Building Challenge (17). The report does not recommend a specific rating or certification system but it does give insight into the efforts, expectations, and focus of the U.S. DOE.

In September 2011, the White House announced the Green Button program as part of its Policy Framework for a 21st Century Grid. Their vision of Green Button was to provide customers access to their energy usage information electronically. With the information at their fingertips, consumers would be enabled to make more informed decisions about their energy use and, when coupled with opportunities to take action, empowered to actively manage their energy use.

[11] Public Law 110–140—DEC. 19, 2007. Energy Independence and Security Act of 2007. (EISA)

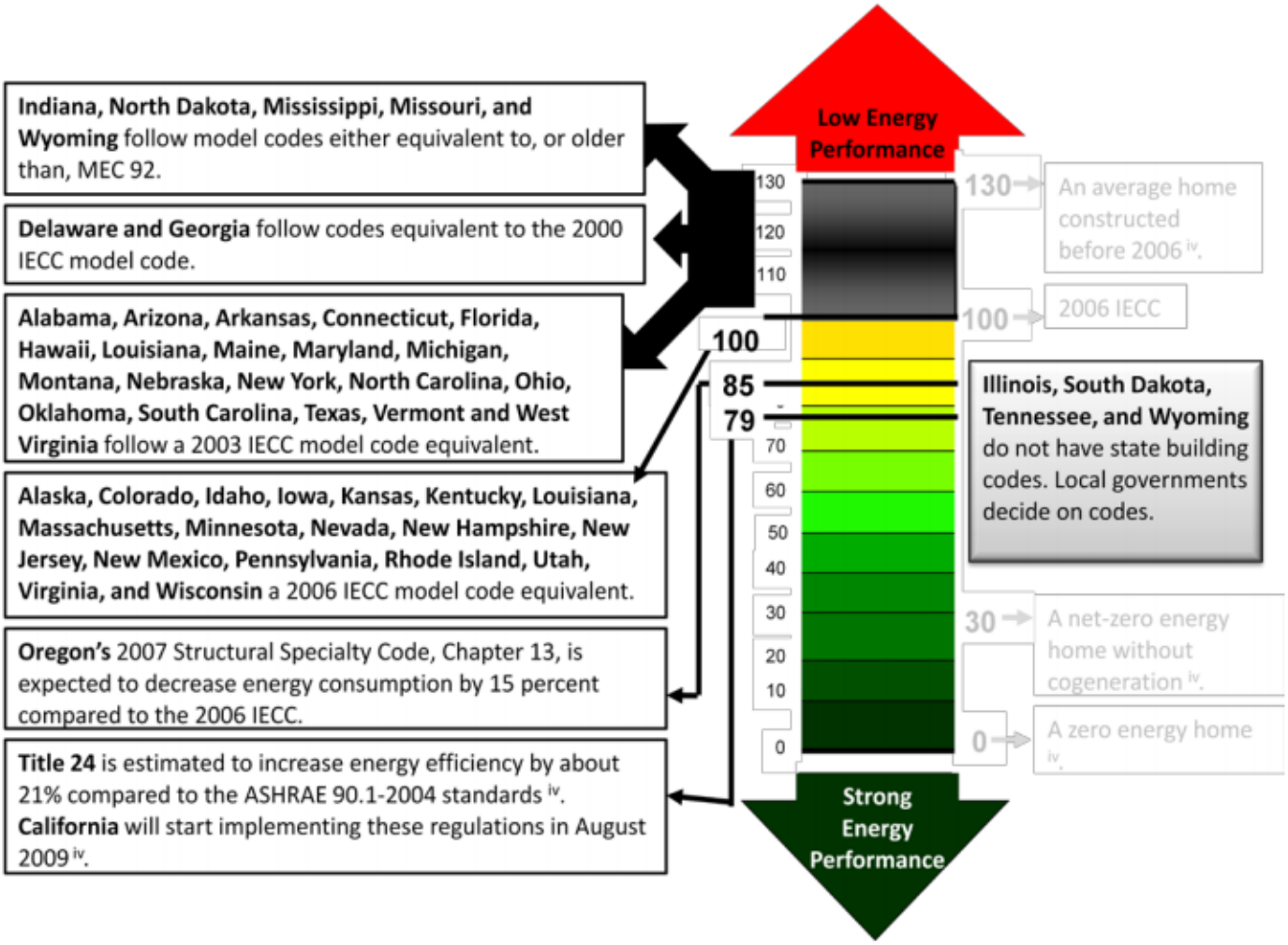
2.2 Federal and State Codes

For successful change, there needs to be cooperation between the federal government, states and local municipalities. This starts with policies written to influence home building energy code development. Building energy codes are minimum requirements for energy efficiency design and construction for new and renovated residential and commercial buildings. Through government incentives, such as rebate and financing programs, states can be encouraged to adopt and enforce a standard measurement system for home energy ratings as a building code for new construction and existing homes.

The lack of uniformity in state and federal codes also contributes to the complexity of quantifying home energy ratings. The Department of Housing and Urban Development (HUD) regulates the energy efficiency requirements for manufactured housing through CFR 3280[12], known generally as the HUD-code. (18) The HUD-code is the only federally regulated building code associated with residential building. Although concrete data does not exist about the Index number for manufactured homes, the Index number is estimated to be above 100 on the HERS Index. (10)

[12] CRF 3280 contains manufactured home construction and safety standards that cover all equipment and installations in the design, construction, transportation, fire safety, plumbing, heat-producing and electrical systems of manufactured homes which are designed to be used as dwelling units.

Figure 1: State Energy Codes on HERS Index



As seen in Figure 1, state codes range greatly in stringency. Figure 1 exemplifies this by using the HERS Index as a measuring stick for each state's minimum building code requirement.

While California has recently adopted Title 24[13], which is estimated to be 30 % more energy efficient than the 2006 IECC, the states of Illinois, South Dakota, Tennessee, and Wyoming have not adopted state-wide energy regulations at all. It should be noted that in many cases local, city or county governments adopt and enforce energy codes. (19) This localized nature of home building codes contributes to the difficulty in discerning the actual energy efficiency of specific states' homes.

[13] California Code of Regulations, Title 24, also referred to as the California Building Standards Code. Part 6 is known as the California Energy Code.

2.3 Energy Ratings

The most common method used to rate a building's energy performance is known as an operational rating. This is the approach used by EPA's Portfolio Manager and by newer building disclosure ordinances such as Boston's Building Energy Reporting and Disclosure Ordinance (8). An operational rating evaluates a building's energy performance based on how it is operating, not on how it is designed. An operational rating uses an energy metric measured based on factors such as building size, weather, and building type. On the plus side, this strategy allows the energy use of very different buildings throughout a large portfolio to be compared. This type of rating can show the effectiveness of energy efficiency investments as well as identify which buildings within a portfolio need more attention. On the negative side however, an operational rating does not take into account occupant behavior. For example there is no way to monitor whether a TV is left on, or whether a water pump is running for too long, or even whether heating and cooling systems are running simultaneously. This key factor is a huge problem in establishing how efficiently a building is operating. Simply put, operational ratings will collect how much energy is being used, not how efficiently it is being used. In summary, operational ratings deal less with a building's designed energy performance and more with how the building is actually operating in comparison with other buildings in the area.

A rating that evaluates how efficiently a building is designed as compared to an established baseline and not how it is operating is known as an as-designed rating. This rating evaluates a building based on the physical characteristics within a building footprint. As-designed ratings are based on how components such as water heaters, heating and ventilation systems, toilets, etc. are supposed to operate based on the specification sheets. By focusing on these built-in characteristics, an as-designed rating reveals a building's intrinsic energy performance, separate from how it is operated. It judges how the building "should" perform, not how it actually performs.

A $100 per month reduction in your utility bills frees enough cash to pay for a $17,000 increase in your mortgage (assuming 6 percent interest over 30 years).

As-designed ratings were developed to enable the real estate market to put a financial value on the energy performance of a building. A strong as-designed rating enables a building owner who invests in energy efficiency to get a return on that investment when they sell the building. In this way, an as-designed rating creates an incentive for energy efficiency investments in buildings (8). As a negative, this rating does not offer data on actual performance. A building could be built efficiently but, for different reasons, be unknowingly running inefficiently. A non-exhaustive summary of some major home energy ratings can be found in Appendix B.

While as-designed and operational ratings separately have distinct pros and cons, a combination of the two is promising. Together, as-designed and operational ratings provide the ability to compare a building's potential energy performance with its actual energy use,

enabling building operators and owners to prioritize actions that will reduce energy use. Additionally, operational ratings of existing buildings can be used to improve the accuracy of energy models used to create as-designed ratings.

2.4 Adoption of a Standard Measurement system

The market's ability to understand all of the ratings –HERS, ENERGY STAR 2006, HES, LEED H, NAHB, Green Globes, Environments for Living, Built Green, etc. – how they compare to one another, which energy labels use which rating and what the options are worth in terms of house values and better quality of life is limited. The use of a standard measurement system as well as the proposed HEPR discussed in section 6.4 would offer solutions to these issues.

Although many organizations do recognized the need to quantify the efficiency of their particular ratings on a scale, there is little action taken.[14] There are three areas that, if persistently addressed, could lead to America's successful adoption of a standard measurement system for home energy ratings. The first is market confusion due to the vast number of ratings available[15]. Secondly, ratings don't offer residents what they want; quantifiable clear-cut data they can understand, use and trust[16]. Thirdly, there is no national standard that regulates and guides home rating systems and programs. While not perfect, the HERS Index discussed below does use a metric as its benchmark for all homes. This same strategy can be modeled when creating a standard measurement system that considers more than just as-designed data.

2.5 The HERS Index Explained

The Residential Energy Services Network (RESNET), a not-for-profit national association of home energy raters and energy-efficiency mortgage lenders, developed the HERS index in 2006. HERS is an as-designed rating which was developed to qualify homes for energy efficient mortgages by measuring the monetary savings attributable to the energy efficient features of a home. To calculate the HERS Index score of a particular residence, an auditor inspects a home's heating and cooling efficiency, insulation levels, appliance and lighting energy use, window efficiency, a home's solar orientation, and other factors that are tailored to the home's climate regions, and enters the findings into a certified software program. The software compares the findings against a reference home to determine the home's HERS score. The reference home, used as a benchmark with a score of 100, is a model home designed to imitate the home being rated, ensuring the score is always relative to the correct size, shape and type. A home's HERS

[14] ASHRAE is currently working on its Standard 214P, Standard for Determining and Expressing Building Energy Performance in a Rating Program.

[15] Homebuyers, after becoming accustomed to hearing about HERS ratings, are now being introduced to HES, completely different system which cannot be compared to HERS.

[16] The White House Office of Science and Technology Policy (OSTP) released a Call-to-Action in 2011 to provide consumers with easy-to understand data about their household energy use. This led to the creation of Green Button.

score is based on deviation from the reference home's score. For example, a home with a HERS Index Score of 70 is 30% more energy efficient than a standard new home while a home with a HERS Index Score of 130 is 30% less energy efficient than a standard new home. RESNET defines an average new home as a home that meets the 2006 IECC. On average, a home built before 2006 in the United States has an Index number of 130. Seventeen state governments have adopted the 2006 IECC as a state code. (10) However, it should be noted that many states enforce less stringent codes, while other states, such as California and Oregon, enforce stricter energy efficiency codes. HERS is used as a requirement for several federal programs including ENERGY STAR for Homes and a federal tax credit for new homes.

Presently, RESNET's HERS Index is calibrated according to the energy efficiency of the ICC's 2006 IECC mandates. As explained previously, the 2006 IECC has an Index number of 100. Therefore, to determine the HERS Index number of other energy efficiency programs, one must compare the programs to the 2006 IECC; see Table 1. Since each 1 percent increase in energy efficiency corresponds to a 1 point decrease on the HERS Index, simply knowing the percentage that a particular energy efficiency program is better or worse than the 2006 IECC provides enough information to assign a program an Index number, as seen in Figure 1. (10)

Table 1: Home Type Definitions

Home Type (Index Number)	*Definition*
Typical U.S. Home (130)	Built before 2006
New Home (100)	Complies with the 2006 International Energy Conservation Code (IECC) mandates.
Net-zero Hoe With Cogeneration (0)	Produces as much energy as consumed through a cogeneration system.

Recent studies indicate that residential and commercial building sectors account for 74% of electricity consumption and represent more than 40% of total US energy use. Housing is responsible for more than 20% of that energy appetite, surpassing commercial buildings (3). The numbers are not surprising when looking at the implications of the new gadget age where TVs, computers, cell phone chargers, and soon to be electric vehicle charging stations fill almost every home. In 1950, television penetration of U.S. households was only 9.0%. Today it is almost 99% and the average American home has more television sets than people (20).

A shift to efficiently operating a home instead of simply counting the number of energy efficient appliances within it is key in getting households to adopt genuine energy saving behaviors. While energy management has been popular in larger buildings for a long time, it has only recently started catching on in homes. Most homeowners are not even aware of the term and take more of a haphazard, flying-blind approach to reducing their energy consumption. Energy management is just as effective in homes as it is in larger buildings and deserves more attention since the residential sector was accountable for over 20% of the 97.53 quadrillion BTUs the US used in 2013. (21) In 2011, if residential energy used in US homes could be lowered by as much as 30%, the energy saved would have met the average annual energy needs of nearly 63 million US homes (22).

3.2 Controlling Energy Consumption and Cost

The savings realized by data gathered by smart meters[17] depends largely on the actions taken with the data. Estimates of energy savings have ranged from 1% to 20%, depending on the application of a metering system. (23) As seen in Table 2, the low-end savings of 0% to 2% is generally attributed to the "Hawthorne Effect," a phenomenon whereby individuals alter their behavior when they know they are being studied. These savings quickly erode if the occupants realize that the meter data is not being used. To maximize energy savings, the data must be used to drive action.

Table 2: Expected energy savings from utility metering

Action	*Observed Savings*
Installation of Meters	0% to 2% The Hawthorne Effect
Bill Allocation Only	2.5% to 5% Improved Occupant Awareness
Building Upgrade and	5% to 15% Improved Awareness, Identification of Simple Operations and Maintenance Improvements and Managing

[17] A smart meter is a device used by an electric utility that measures electrical energy consumption by the electric consumer at the home and is capable of sending electric energy usage information through a communications network to the electric utility.

Energy Management	Demand Loads Per Electric Management Rate Schedules
Ongoing Management	15% to 45% Improved Awareness, Ongoing Identification of Simple Operations and Maintenance Improvements and Continuing Management Attention

Technology exists that allows users to view how much electricity each and every device in their home is using (4). For example, let's say you own a home and you pay 8 cents per kilowatt hour (KWh) and you install 1.5 KWh hour air conditioning units in two rooms. If you ran both of the air conditioners all day for an entire month it would cost $172.80. If a homeowner could see that air conditioning was costing them this much they might be more inclined to shut the units off, consolidate, or consider a central air system.

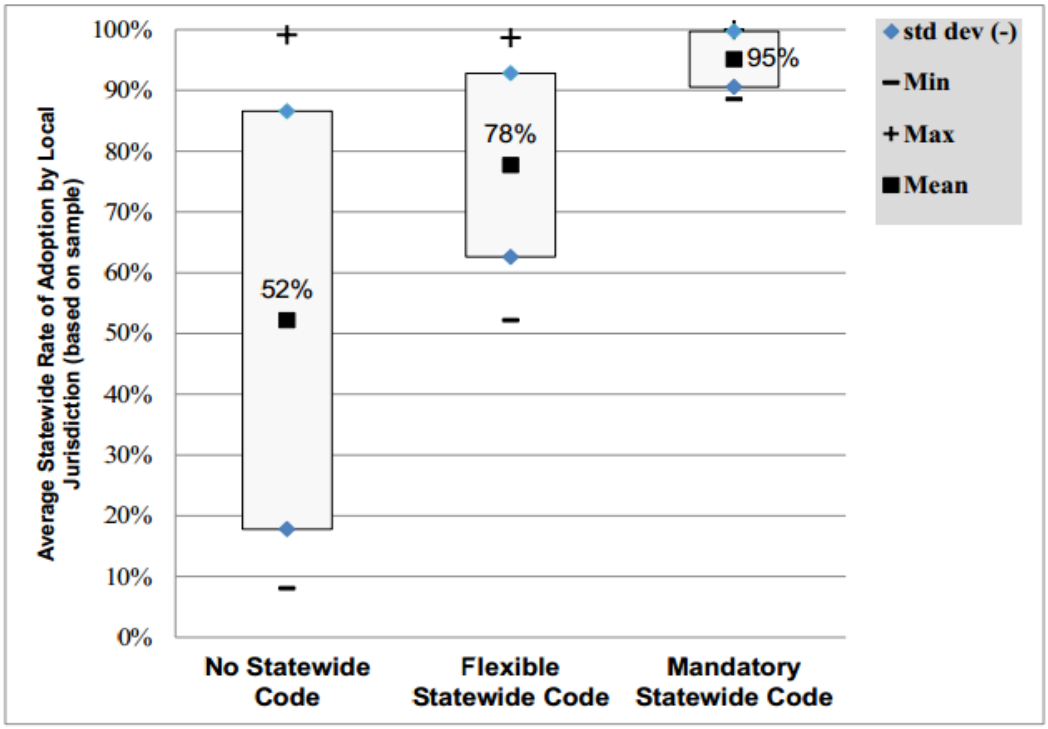
The access to data would also enable home residents to flatten their peak energy demand and avoid peak-power prices by shifting energy use to off-peak hours. This can be accomplished by raising awareness among residents through a display of their energy consumption. A display would allow home occupants to take advantage of low cost demand opportunities that require time-of-day pricing and cooperation with utility companies. The cost and demand benefits would be felt by utility companies as well as home owners. Residents can also validate energy conservation measures making it easier to build a case to upgrade their homes.

3.3 Advanced Metering Infrastructure and Home-Area Networks

The undeniable transition towards a smart grid is opening the door to homes that can monitor and control the energy consumption of every device plugged into them. These abilities are due strongly to the emergence of two technologies; Advanced Metering Infrastructure (AMI) and Home Area Networks (HAN). These technologies have influenced many new products and applications for homes; for example, smart meters, car-charging stations, smart thermostats, renewable-energy installations, and smart appliances.

AMI represents fully integrated, two-way communication technologies that will make the grid a dynamic interactive system for power and real-time data exchange and is an integration of several technologies; a smart meter at the customer's location, a communications network between the utility company and the smart meter, and the HAN to connect the house with the smart meter. A smart meter is the latest version of electric meter installed at the customer's premises. The meter is deemed "smart" because it enables utility companies to perform three main functions: (1) track the electricity used, (2) remotely control appliances on the HAN, and, therefore, (3) remotely control electricity consumption (24).

Colorado municipal utility Fort Collins Utilities is collecting residential smart meter data and putting it out to customers every 15 minutes. That might be fast enough to get people involved in energy on a day-to-day basis, if it's accurate and comes along with information on how they can save money in the process.


Average Statewide Rate of Adoption by Local Jurisdiction (based on sample)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
52%
78%
95%
std dev (-)
Min
Max
Mean
No Statewide Code
Flexible Statewide Code
Mandatory Statewide Code

codes have a relatively high average adoption rate (95 percent) with a very narrow spread (89 to 100 percent) and standard deviation from the mean (25).

The DOE's findings show that average adoption rate for the sampled jurisdictions within states that have a statewide energy code is significantly greater than the average jurisdictional adoption rate of states that do not have a statewide energy code. The U.S. DOE's conclusion was that states which do not have a statewide energy code will, on average, have a lower statewide jurisdictional adoption rate than states that have statewide energy codes (5). These conclusions can be applied to America's energy rating program as well. Without a mandatory nationwide measurement system for home energy rating programs implemented at a state and local level, there will be a much lower adoption and success rate rate.

Government support is one way to push for new policies and is also a deciding factor in their success. Bipartisan congressional support can increase the efficiency of a program by the use of mandates, research funding, and tax incentives in legislation. It is also important to seek priority on the political agenda, and identify the absence of legislation supporting the specific program. Convincing both political parties and both houses of Congress to agree on an idea or plan may be a difficult task if it is not keen to the agendas of all parties involved. Whether talking about research funding, tax rebate programs, or adopting standards into law, plans that make everyone content are the goal, but hardly a reality. Coming up with a program that appeals to the majority of lawmakers and their constituents is a considerable barrier.

Another area that could slow the adoption of a national measurement system is state autonomy. States, counties and home owners may look at a federal program as a restriction of their rights. There needs to be a constant emphasis on the benefits such as energy savings and a higher level of understanding for every home across America.

years to identify a system and certification level "deem(ed) to be most likely to encourage a comprehensive and environmentally sound approach to certification of green buildings." EISA directs the Director of GSA's Office of Federal High Performance Green Buildings to provide the findings to the Secretary of Energy who, in consultation with the Department of Defense and GSA, formally identifies the systems(s) to be used across the federal government. This program could be expanded to evaluate HERs in the U.S. to identify one that will suit the private sector.

5.2 Pending Legislation

In May 2014 the Sensible Accounting to Value Energy Act of 2014 (SAVE)[18] was introduced in the House of Representatives. The bill is meant to improve the accuracy of mortgage underwriting used by federal mortgage agencies by ensuring that energy costs are included in the underwriting process. The intended results are to reduce the amount of energy consumed by homes and to facilitate the creation of energy efficiency retrofit and construction jobs.

In May 2011, the Electric Consumer Right to Know Act or the e-KNOW Act[19] was introduced in the senate to amend the Public Utility Regulatory Policies Act of 1978. The bill would have granted an electric consumer the right to access the consumer's retail electric energy information in an electronic form, free of charge. The bill was read twice and referred to the Committee on Energy and Natural Resources but was not enacted. The bill was reintroduced March 27th 2014 into the senate under a new name; E-Access Act[20]. The main difference between the e-KNOW Act and the new E-Access Act is that it's no longer mandatory for utilities. Utilities are instead incentivized by appropriated funds limited to 10 million dollars for fiscal year 2015 which will remain available until expended. The E-Access Act was read twice and referred to the Committee on Energy and Natural Resources. The Act will most likely not be enacted this year and will be reintroduced in the 114th congress.

- Help all parties understand the effectiveness of U.S. energy efficiency programs and identify where further development is needed;
- Allow homeowners, engineers, contactors, and architects to find and follow optimal building efficiency programs during construction;
- Encourage productive competition between organization and thus the creation of more progressive energy efficiency programs;
- Promote the overall use of more sustainable building practices;
- Help decrease the residential building's large contribution to greenhouse gas production and climate change. In the following centuries, the performance of new US building stock must, and will be forced to, improve significantly. The creation of new energy efficiency programs is inevitable. To help solve national environmental, safety, and security problems and avoid unnecessary confusion, organizations must immediately start contributing to and using a common measurement system.

6.2 Use an Index Similar to the HERS Index

RESNET's HERS Index is a useful comparison tool ready to be used today. Some of the advantages of using an index similar to the HERS Index are:

- Less research and development, and therefore money, is needed;
- Many, although not all, building organizations already compare and calibrate their own programs according to the HERS Index;
- The building industry and personnel who would use the HERS Index on a regular basis are already familiar with the tool;
- Software to calculate a home's energy use is already developed.

Recommended changes to the HERS Index are:

- Invert the scale so more energy efficient homes come in higher rather than lower. In education, a score of zero is seen as bad, in the HERS Index it is a perfect score. A scale where a lower score is good is easy to understand for golfer's maybe, but it's counterintuitive for others.
- Have the index account for operational performance by using energy data gathered by smart meters. While not possible currently, this recommendation is in preparation for a society where smart homes are the norm. As detailed energy data becomes more available, the index should be able to take it into consideration when rating a home.
- Use California's TDV strategy outlined in Appendix D.

6.3 Balance State and Federal Rights

Although the lack of a federal residential building code adds greatly to the complexity of the U.S. building system, it is vital to respect states' rights and sovereignty. Allowing each individual state to adopt separate energy rating codes alongside the mandated rating allows for the continual progression of safer and more stringent energy efficiency measurements. If all states had to conform to using only one energy rating, states such as California and Oregon would not be as progressive. While a standard rating code must be used as a minimum, states

have the option to use others along with the standard if they choose. It is imperative that these states take the lead in energy efficiency programs because it eases the future adoption of progressive energy codes in other states. At the very minimum, to ensure the safety and health of occupants, all states need to start adhering to the standards set by the 2006 IECC. Currently a variety of states, all with different climate, geographical and monetary priorities, have mandated the 2006 IECC. From Nevada to Massachusetts to Louisiana, these states have shown that the adoption of a stringent energy efficient code is possible anywhere. Since buildings are the greatest contributors to greenhouse gases in the US, steps need to be taken to instate mandatory minimum energy codes. Unless local, state and federal agencies do their part to ensure long-term adoption and compliance, the U.S. could end up putting a shiny green stamp on a generation of unsustainable homes.

6.4 Introduce the Home Energy Performance Rating

The proposed HEPR outlined in Appendix C would utilize as-designed and real time operational data to enable home residents to truly understand the energy used by their homes. The prospect of utilizing the operational energy data from smart meters is exciting for a number of reasons, including: (1) how it might motivate people to address evaluation of energy-efficient homes in the home sale process; (2) how it can encourage energy efficiency upgrades for sellers aiming to make their home stand out in the market and/or for new buyers; (3) how it can generate information needed for better valuation of energy efficiency in homes for appraisals and mortgage underwriting; and (4) how it can make home energy rating programs more clear-cut, inclusive, and consistent.

The HEPR structure would use the proposed standard measurement system and highlight the importance of energy data collected by smart meters to adjust for variables such as geography, number of occupants, and number of appliances. This would benefit home marketing, reduce rating disorganization, flatten peak electricity demand and create a rating that homeowners everywhere are more likely to trust, comprehend, invest in and profit from.

See appendix C for the HEPR basic outline.

6.5 Getting Recommendations through Congress

Following in the footsteps of the E-Access Act, a new bill should be introduced in the Senate of the 114th Congress by Senator Mark Udall (D-CO) and Senator Ed Mackey (D-MA). Senator Udall serves on the committee of energy and natural resources and Senator Mackey has extensive energy and environmental legislative achievements. Due to their background, both Senators would be effective sponsors of a bill incorporated into Shaheen-Portman that amends Section 436(h) of the energy Independence and Security Act (EISA) and expands on the E-Access Act, pending its enactment. The amendment to EISA should require the GSA to evaluate the ICC 700 and recommend an accurate measurement system for a wide variety of U.S. homes instead of just government buildings. The expansion on the E-Access Act should emphasize the importance of using smart meter data. In drafting the bill, all listed entities are encouraged to take part:

- State and local regulatory authorities, i.e. the National Association of Regulatory Utility Commissioners.
- Appropriate Federal agencies, i.e. the National Institute of Standards and Technology.
- Consumer and privacy advocacy groups.
- Utilities.
- The National Association of State Energy Officials.
- Other appropriate entities, i.e. groups that represent demand response and electricity data devices and services.

sustainable practices, but also demonstrates a progressive and necessary movement synonymous with sustainability. Certification fees are tiered based on project square meters and are paid prior to audit.

Living Building Challenge, unlike other rating systems, is more diversified. The projects are not rated solely on their energy consumption. A large factor is their impact on the surrounding environment. Being diversified does not come without shortcomings, though. The program does not give quantitative efficiency data about the mechanical appliances within the home. This aspect takes away from the rating's ability to give the user valuable information about their home.

Building Research Establishment Environmental Assessment Methodology (BREEAM)

BREEAM international was first published by the Building Research Establishment (BRE) in 1990 and is arguably the world's longest established and most widely used method of assessing, rating, and certifying the sustainability of buildings. "BREEAM soon formed the basis for numerous other rating systems that followed, including LEED®, Green Globes, Green Star, and other like systems (28)." The Code for Sustainable Homes (CSH) is an environmental assessment method for rating and certifying the performance of new homes based on BRE's Global EcoHomes scheme. It is a European government-owned standard intended to encourage continuous improvement in sustainable home building. An initial assessment is carried out at the design stage. This is based on detailed documentary evidence and commitments which results in an interim certificate of compliance. Final assessment and certification is carried out at the post construction stage. Based on the design stage review, this includes a confirmation of compliance, including site records and visual inspection, and results in a final certificate of compliance.

Building plaques are available to purchase for buildings which have achieved final post-construction certification (if BREEAM New Construction) or which have a valid BREEAM In-Use certificate. BREEAM In-Use plaques must be removed immediately if certification expires or is withdrawn for any reason.

Appendix B: Types of Home Energy Ratings

Home Energy Rating Score (HERS)

The HERS rating was established in 2006 by the Residential Energy Services Network (RESNET), a California-based national association of home energy raters and energy-efficiency mortgage lenders. HERS is an operational rating which was developed to qualify homes for energy efficient mortgages in 2006. To calculate a home's HERS Index Score, a certified RESNET HERS rater enters data about the home into a certified software program and compares the data against a reference home. The reference home is a model home designed to imitate the home being rated, ensuring the score is always relative to the correct size, shape and type. The reference home is used as a benchmark with a score of 100. A home's HERS score is based on deviation from the reference home's score. For example, a home with a HERS Index Score of 70 is 30% more energy efficient than a standard new home while a home with a HERS Index Score of 130 is 30% less energy efficient than a standard new home. HERS is used as a requirement for several federal programs including FHA Energy Efficient Mortgage, ENERGY STAR for Homes, and a federal tax credit for new homes. Likewise, government agencies such as the department of housing and urban development (HUD) and the EPA recognize the HERS index as an official verification of energy performance (29).

One large problem with the HERS rating is its inability to account for variations in home appliances. For instance, the reference home has one clothes dryer and one clothes washer. If the home being rated was built without a clothes dryer, the software still assumes that a clothes dryer is there, even when one isn't. The result will be that the home seemingly uses less energy than the software would predict.

While the HERS rating is a useful metric, it doesn't tell you how much energy a home will use. Of course, it's a good sign if a home has a low HERS index but just because your house has a low HERS index doesn't mean that your home is necessarily efficient.

Home Energy Score (HES)

The U.S. Department of Energy HES was developed in 2010 by Lawrence National Laboratory in an effort to create a simplified and accurate building rating program. HES is used as a rating tool by the Building Performance Institute, Inc. (BPI) in its national rating program called Building Energy Rating System (BERS). The goal of BERS is to provide customers with an affordable, easy to understand rating of their home that can be combined with a comprehensive home energy audit. The score reflects the energy efficiency of a home based on the home's structure and heating, cooling and hot water systems.

The process starts with a home energy score qualified assessor collecting energy information during a brief home walk-through. The assessor then scores the home on a scale of 1 to 10. A score of 10 indicates that the home has excellent energy performance. A score of 1 indicates the home needs extensive energy improvements. In addition to providing the score, the qualified assessor provides the homeowner with a list of recommended energy improvements and the associated cost savings estimates.

Both HERS and HES are federal programs established through government agencies but their differences are surprising:

Table 3: HES vs. HERS

	HERS	HES
Home Types	New and Existing	Existing Only
Scale	0 to 100+ Lower is better; granular detail	1 to 10 higher is better; no net zero equivalent
Occupancy	# of bedrooms +1	# of bedrooms
Validation	3rd party rater	HES Qualified Assessor
Scoring Reference	2006 IECC reference home	HEST and EIA RECS data
Quality Assurance	Provider / designee review 1% / 10% of rated homes; documented program	re-score 5% of homes; unclear QA program
Diagnostic Testing	required	not required
Compliance	ANSI Home Energy Ratings standard; recognized option for energy codes	
Market Leverage	new homes tax credit; FHA / VA Energy Efficient Mortgages; ENERGY STAR for Homes; other programs	
Average Cost	$500 per home	$25 - 100 per home

Energy Performance Score (EPS)

EPS is a combined asset and operational rating that was co-developed by Earth Advantage's Institute and Energy trust of Oregon. The EPS provides a way to estimate home energy consumption, related carbon emissions, and utility costs. EPS is a voluntary score that builders request before construction which requires a third party verifier to analyze the home's features and construction techniques as well as test performance factors. The EPS allows for

comparisons of one home's energy use to another, without the influence of varying occupant behavior. Homeowners can also use the tool to compare the typical energy use of the house in its current state versus what it could be like after energy upgrades.

EPS does not allow users to monitor their home post-upgrades without having another audit done on their home. Even once another audit is completed, the home owner will only know whether they are or aren't saving energy. It does not give them any insight as to how efficient their home is or how efficiently they are using their home.

Building Energy Quotient (bEQ)

ASHRAE's building energy quotient (bEQ) does not currently cover residential but the program structure would serve well if used for singe family, low-rise, and high-rise homes. The bEQ rating allows commercial building owners to receive an as-designed rating, operational rating, or both. Scores range from 0 to 145 or more and correlate to different letter grades; A+ to F (not including E). A score of 0 merits a grade of "A+" ensuring a building to be 'zero net energy' while a score of 145 or more will merit an "F" for unsatisfactory. Only Professional Engineers and ASHRAE Certified Professionals can submit completed workbooks to ASHRAE for review and receive ASHRAE issuance of a building rating.

To receive a bEQ certification, the building owner retains and pays an assessor directly based on negotiated fees. The assessor performs an assessment and pays a registration fee of approximately $500 to ASHRAE when submitting documents reviewed by the bEQ committee.

While bEQ does not currently rate homes, the rating system fundamentals have been completed and would work well as the framework for a nationwide residential building energy rating and labeling program. The bEQ's operational rating is more comprehensive than most available due to its focus on the building's metered energy use for the preceding 12 to 18 months. Coupled with a data collection system, bEQ's ratings would permit home owners to actively monitor their energy usage in a way that would result in energy efficient behavioral changes.

- The program funds would be granted by a federal organization such as the DOE or EPA and involve volunteer efforts from industry organizations such as USGBC and ASHRAE; Participation in the pilot would be state-mandated and implemented in 50% of qualified new and existing homes within the first year;
- Work with stakeholders to adopt effective, transparent practices for the evaluation, measurement, and verification of energy efficiency savings.

Developing State Policies to Ensure Energy Efficiency Practices:

- Have a mechanism to review and update local and state residential energy efficiency codes to ICC 2009 IECC requirements;
- Establish enforcement and monitoring mechanisms of the energy efficiency codes;
- Adopt and implement state-level appliance standards for those appliances not addressed by the federal government;
- Develop and implement lead-by-example energy efficiency programs at the state and local levels.

Future National Implementation:

- Consider a transition from the pilot to a broader nationwide program based on the results from an evaluation of the pilot;
- Establish a minimum size threshold (i.e. 1,000 square feet) to be included in a building energy labeling program;
- Renewal of the HEPR every 10 years, with specific events triggering earlier renewal;
- Expansion of efforts like Green Button to continue development of a database to provide appropriate stakeholders with access to rating and label information in order to compare energy performance.

17. Laboratory, Pacific Northwest National. *Green Building Certification System .* s.l. : U.S. Department of Energy, 2012.

18. Donovan, Secretary Shaun. U.S. Department of Housing and Urban Development. [Online] http://portal.hud.gov/hudportal/HUD?src=/program_offices/housing/ramh/mhs/faq.

19. Commission, California Building Standards. California Code of Regulations, Title 24, Part 6. [Online] http://www.documents.dgs.ca.gov/bsc/Title_24/documents/2010/Part%206/2010-CA-Energy.pdf.

20. Basics, Television. A Report on the scope and growth of televisions. [Online] 2012. http://www.tvb.org/media/file/TV_Basics.pdf.

21. Administration, U.S. Energy Information. Annual Energy Outlook 2013. [Online] 2013. www.eia.gov/forecasts/aeo.

22. —. Residential Energy Consumption Survey data show decreased energy consumption per household. [Online] U.S. Department of Energy, 2012. http://www.eia.gov/todayinenergy/detail.cfm?id=6570.

23. *Making the Case For Energy Metering.* Plourde, Jim. April, 2012, ASHRAE.

24. Ofei-Amoh, Kweku. Smart-Grid Technologies . [Online] 2013. http://www.electri.org/research/smart-grid-installation-and-construction-management-aspects-electrical-contractors.

25. Labratory, Pacific Northwest National. Rates of Building Energy Code by Local Jurisdictions. [Online] 2012. http://www.energycodes.gov/sites/default/files/documents/BEC_Statewide_Adoption.pdf.

26. Commission, The California Energy. What is You're Home Energy Rating? [Online] 2009. http://www.energy.ca.gov/2009publications/CEC-400-2009-008/CEC-400-2009-008-BR.PDF.

27. Sheer, Roddy. The Living Building Challenge. [Online] 2013. http://www.emagazine.com/earth-talk/the-living-building-challenge.

28. Method, Building Research Establishment Environmental Assessment. Building Wise. [Online] BREEAM, 2014. http://www.buildingwise.net/breeam.

29. RESNET. Home Energy Rating. [Online] 2014. http://www.resnet.us/energy-rating.

30. Administration, U.S. General Service. Green Building Certification System Review. [Online] http://www.gsa.gov/portal/content/131983?utm_source=OGP&utm_medium=print-radio&utm_term=gbcertificationreview&utm_campaign=shortcuts.

31. Dillon, Monica. Appraisal Values for Energy Star Certified Homes. [Online] Hearst Newspapers, 2014. http://homeguides.sfgate.com/appraisal-values-energy-star-certified-homes-77996.html.

32. 110–140, Public Law. Energy Independence and Security Act of 2007. 2007.

33. Department, Energy Services. Watts Up? Energy Saving Tips. [Online] San Diego, 2014. http://www.sandiego.gov/environmental-services/energy/conservation/wattsup.shtml.