Comparative Analysis of U.S. and China Building Energy Rating and Labeling Systems

Kevin Mo and Lane Burt, Natural Resources Defense Council, USA
Bin Hao and Jie Cheng, Center for Building Energy Efficiency, MOHURD, China
Andrew Burr and Sonal Kemkar, Institute for Market Transformation, USA

ABSTRACT

Rating the energy performance of buildings is an emerging policy tool in both the United States and China. Although rating policies and practices between the two countries differ in terms of approach, structure, administration and support, the goal of encouraging greater energy efficiency and fewer greenhouse gas emissions in the building sector is shared.

This paper provides the first comparative analysis between building energy rating policies in the United States and China. The United States has several rating and labeling systems either deployed to the market or under development, while China's Ministry of Housing and Urban-Rural Development is piloting a more comprehensive building rating and labeling program. This paper dissects the policies and programs in each country and explores opportunities for alignment related to rating methodology, policy structure, program administration and workforce development. It concludes that many challenges and opportunities in building energy rating are similar in the United States and China, and that both countries stand to benefit from greater collaboration and the sharing of best practices related to building energy rating.

Introduction

Research has shown that the building sector has the largest potential for greenhouse gas emissions reduction worldwide (Choi Granade et al. 2009; UNEP 2007). In many cases, energy efficiency is the low-hanging fruit by which energy and greenhouse gas emissions can quickly and significantly be reduced in buildings. As the world's two largest GHG emitters, China and the United States have integrated building energy efficiency into their respective climate change strategies. The two nations formalized collaboration on improving building energy efficiency by signing the "US-China Energy Efficiency Action Plan" on November 17, 2009, when U.S. President Obama met Chinese President Hu Jintao in Beijing (White House 2009). Recognizing that "the United States and China consume over 40 percent of global energy resources, costing business and households in the two countries roughly $1.5 trillion per year", the United States and China vowed to collaborate on "energy-efficient building codes and labels" as well as other areas to achieve greener buildings and communities.

There are considerable commonalities and differences to existing labels and emerging rating and labeling processes in the United States and China. Harmonizing labeling infrastructures and outputs between the two countries would remove investment barriers in building energy efficiency and send a strong message to other nations worldwide about the importance of building labeling. However, at this early stage in the collaboration, a simple comparative analysis on labeling practices in the United States and China could be valuable to stimulate information exchange between the nations and begin to align broad labeling concepts.

This paper examines best practices and analyzes alignment opportunities in current and emerging labeling systems in the United States and China. Profiles of rating and labeling systems include the Chinese building rating and labeling program being developed by the Ministry of Housing and Urban-Rural Development (MOHURD) and several rating and labeling systems in the United States, including: the Home Energy Rating System (HERS); the ENERGY STAR for Commercial Buildings program; and the emerging ASHRAE Building EQ label for commercial buildings.

The paper also explores what the U.S. and China can learn from each other in terms of building labeling technology, development processes and policy framework, and to what degree rating and labeling concepts may be harmonized.

China's MOHURD Rating and Labeling Program

In China, MOHURD is developing a national building energy rating and labeling program based on Chapter 2 Article 21 in the Civil Building[1] Energy Efficiency Regulation, (Chinese State Council 2008) released in 2008. The regulation legally requires that "the energy performance of new government-owned office buildings or large public buildings[2] should be rated and labeled". The national labeling program is now being piloted in eleven cities and seven provinces. Several provincial and municipal governments have also developed their local building labels, such as China's first building rating standard released in Shanghai (SRESRI 2008) with technical and policy assistance from the U.S. Residential Services Network (RESNET) and Natural Resources Defense Council (NRDC).

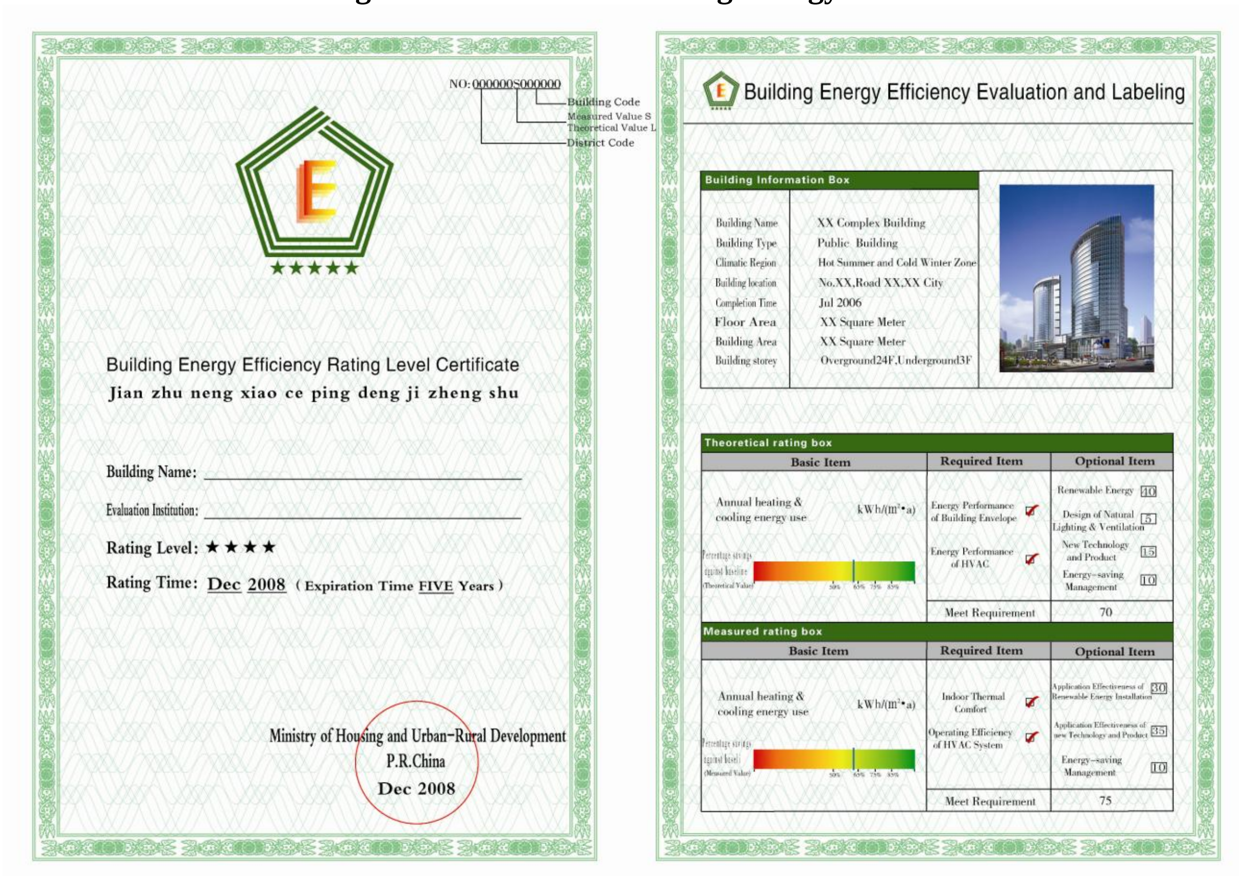
Whereas commercial and residential rating systems are generally segmented in the United States, the MOHURD program covers both residential and non-residential buildings with both asset and operational values. It is voluntary to label residential buildings and most non-residential buildings, but four types of buildings are required to obtain building energy labels: 1) new government-owned office buildings or large public buildings, 2) existing government office buildings and large public buildings that apply for government funding to subsidize energy retrofits, 3) state or provincial energy efficiency demonstration buildings, and 4) buildings that apply for National Green Building Labels (MOHURD 2006).

The MOHURD rating program has five levels, from one star to five stars, with the five-star level representing the most energy efficient. The rating level is determined by parameters in three categories: Basic Items, Required Items and Optional Items. Figure 1 shows the MOHURD building energy label.

- **Basic Items** refer to regulated[3] energy use per square meter, obtained by simulation or measurement.
- **Required Items** refer to minimum performance requirements for building enclosure and HVAC.
- **Optional Items** refer to application of renewable energy, innovative energy efficient technologies, or energy management systems that exceed the standards.

[1] In China, civil buildings refer to residential buildings and public buildings. Public buildings include all non-residential buildings, such as government-owned office buildings, private-sector office buildings, hotels, schools, hospitals, airports, and shopping centers, etc.
[2] Large public buildings refer to those larger than 20,000 square meters.
[3] Chinese residential building energy standards only regulate heating and cooling energy use. The public building standard also regulates mechanical ventilation and lighting energy use.

Figure 1. MOHURD Building Energy Label



Source: www.chinaeeb.gov.cn

Asset Rating Label and Operational Rating Label

As shown in Figure 1, the label can include two ratings[4] obtained at different stages: asset rating as well as operational rating. After a building passes the completion inspection, the building owner applies for a **theoretical rating label** by submitting simulated asset value; the label expires after 12 months. After the building has been occupied for a period of time, the building owner commissions a building rating agency to conduct continuous energy measurement and auditing for no less than one year. The result of the measured energy use produces a **measured rating label,** which is an operational rating label effective for five years.

Climate Zones and Building Energy Standards

A building's asset rating is tied to the building standard applicable in its climate zone. China has five climate zones (see Figure 2): Severe Cold (SC), Cold (C), Hot Summer and Cold Winter (HSCW), Hot Summer and Warm Winter (HSWW), and Mild (M).

Residential buildings in four climate zones are governed by three building standards (Table 1) and all non-residential buildings are regulated by one national building energy standard

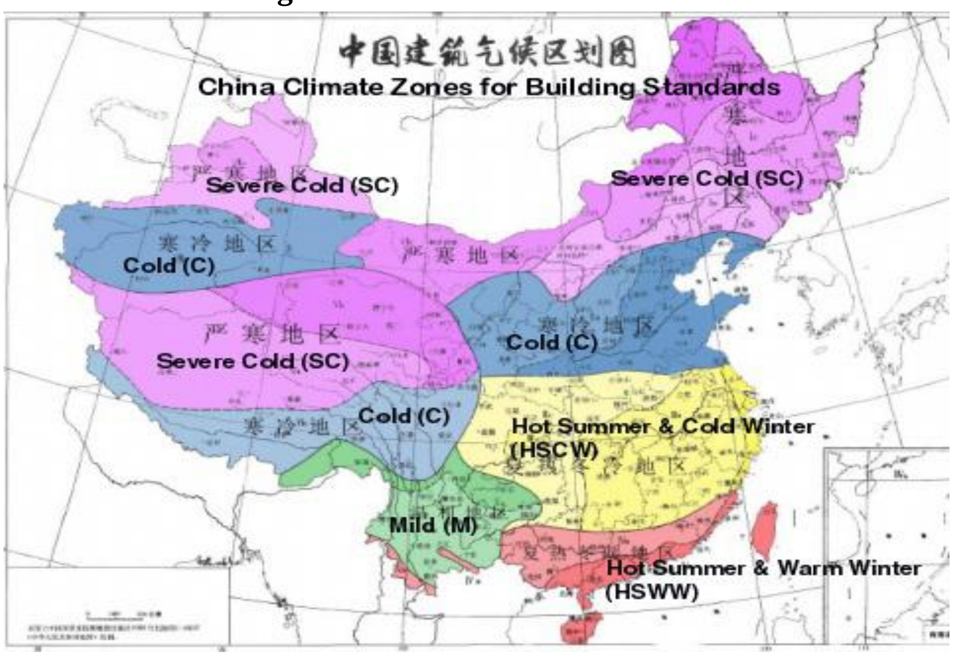
[4] In this paper, "asset rating" and "theoretical rating" are interchangeable, so are "operational rating" and "measured rating".

GB 50189-2005. Residential buildings in the SC and C zones are benchmarked against a fixed value—heat loss (w/m^2) that is a function of the local average outdoor temperature in the heating season. This method is similar to the Russian Energy Passport Program (Chao et al. 2006). Residential buildings in the HSCW and HSWW zones are evaluated against reference buildings specified in respective residential building standards.

All national standards specify a minimum goal of cutting regulated energy use[5] by 50 percent against the baseline. Therefore, national standards are usually referred to as the "50 percent standard".

Local governments can make more stringent building standards. For example, the Beijing local building standard requires a minimum reduction of regulated energy use by 65 percent against the same baseline, and is therefore referred to as the "65 percent standard".

Figure 2. Climate Zones in China



Source: Civil Building Thermal Design Code GB 50176-93

It should be noted that, in China, a "50 percent energy efficient building" just meets the minimum requirements set by the building energy standard. In the U.S. context, however, a "50 percent energy efficient building" means the building is 50 percent more efficient than the standard compliant building.

[5] China's three residential building standards only regulate heating and cooling energy use, and the non-residential building standard also regulates energy use for mechanical ventilation and lighting. Water heating, plug load, and miscellaneous energy use, etc, are not regulated.

Table 1. Residential Building Standard by Climate Zone

Climate Zone	National Standard	Typical Building	Benchmark Methodology	Goal of Standard: 50% reduction
Severe Cold (SC)	JGJ 26-95	Heating only. No cooling.	**Fixed value for each city:** Heat loss (w/m2) calculated from generic residential building design in 1980-1981.	Reduce heat loss by **50%** (30% from building enclosure improvement plus 20% from more efficient heating system)
Cold (C)				
Hot Summer Cold Winter (HSCW)	JGJ 134-2001	No heating and no cooling. Very low comfort level.	**Virtual reference building** that would increase comfort level by adding heating **and** cooling systems to maintain indoor temperature at 18^{o}C (winter) and 26^{o}C (summer), with similar insulation level in the 1980s and standardized heating and cooling systems.	Achieve **50%** reduction of annual total heating and cooling energy use by improving building enclosure, heating and cooling systems.
Hot Summer Warm Winter (HSWW)	JGJ 75-2003		**Virtual reference building** that would increase comfort level by adding heating (north zone of HSWW only) and cooling systems to maintain indoor temperature at 16^{o}C (winter) and 26^{o}C (summer), with similar insulation level in the 1980s and standardized heating and cooling systems.	
Moderate (M)	No National Standard			

Source: Chinese residential building standards JGJ26-95, JGJ 134-2001 and JGJ75-2003

Asset Rating. The Basic Item – annual energy use per square meter – is central to a building's rating result. The percentage savings of the annual energy use per square meter against the baseline determines the star level.

For residential buildings, the calculations for buildings in the SC/C zones and in the HSCW/HSWW zones are different. Residential buildings in the SC/C zones use a fixed value of heat loss (w/m2) as reference. For example, the baseline value of heat loss in Harbin is 33.7 w/m^2. The maximum heat loss of a compliant residential building is 16.8 w/m^2. Residential buildings in the HSCW/HSWW zones and all non-residential buildings are evaluated by performance simulation against reference buildings specified by respective building standards, similar to the reference building approach used by the U.S. Housing Energy Rating System (HERS). The difference is that HERS uses a scale of zero to 100, and the Chinese rating uses the five-star level.

Table 2 shows how a building's rating level is determined once all the three rating items are evaluated. For example, when the asset value is 50 percent to 65 percent efficient against the baseline, the theoretical rating is one-star, given that all required items meet the building standard requirements. When the score of optional items is over 60 points, one more star is added to the rating.

Table 2. Determination of Building Rating

Energy Savings of Basic Items (asset value) to Baseline	Required Items	Optional Items	Star Level
50-65%	Satisfy all requirements	Add one more star when score over 60 points. Maximum is 100 points. The highest level is five star	★
65-75%	Satisfy all requirements		★★
75-85%	Satisfy all requirements		★★★
Over 85%	Satisfy all requirements		★★★★
	Satisfy all requirements		★★★★★

Source: Hao et al. 2009

Operational Rating. The actual energy use is measured and recorded on the certificate. However, it does not change the rating level previously determined by the asset rating, even if the actual percentage of energy savings is lower than simulation, unless the Required Items fail. Although it recognizes the equal importance of asset rating and operational rating, MOHURD has not figured out how to integrate the two ratings into one rating system.

U.S. Rating and Labeling Programs

Residential Rating Systems

In the U.S., rating programs for residential buildings and commercial buildings are usually separated.

HERS. For residential buildings, the most established U.S. building energy rating system is the Home Energy Rating System (HERS) Index created by RESNET. RESNET is a national nonprofit standards-setting organization that maintains the HERS Index criteria, certifies "providers" to train and certify Home Energy Raters, and certifies software to produce the HERS Index (RESNET 2010). The HERS Index is an asset rating, and the details of asset ratings will be discussed later in the paper.

The HERS index uses a scale from 0 to 100 or more, where 0 represents a zero net-energy home and 100 represents a home compliant with the national model energy codes circa 2004. To generate a numerical score, a Home Energy Rater performs a detailed energy audit, including a blower door test (determining the leakiness of the home) and a duct leakage test. These data points are the basis for the simulation of the home under standardized operating schedules and regional weather.

The HERS Index is the foundation for the U.S. Department of Energy's Energy Smart Home Scale (E-Scale) used in the Builder's Challenge program and the U.S. Environmental Protection Agency's ENERGY STAR for new homes program.[6][7] It is also the basis for a California labeling program administered by the California Energy Commission.[8]

[6] http://www1.eere.energy.gov/buildings/challenge/energysmart.html
[7] http://www.energystar.gov/index.cfm?c=new_homes.hm_index
[8] http://www.energy.ca.gov/HERS/

ENERGY STAR homes energy yardstick. Administered by EPA, Home Energy Yardstick is a rating tool measuring the operational energy efficiency of homes. Nontechnical information, including simple building data and utility bills, is input into the program by homeowners without expert guidance. The tool generates a score from 0 to 10; however Home Energy Yardstick is not considered a full energy label.[9]

Commercial Rating Systems

ENERGY STAR portfolio manager. Portfolio Manager is a nonresidential building energy rating tool for existing buildings administered by U.S. EPA. It was introduced in 2000 and has since become the most widely used commercial building energy rating tool in the U.S. marketplace. Cumulatively, more than 13 billion square feet of nonresidential floor space has been rated using Portfolio Manager since its introduction (EPA 2009, 2) That figure accounts for roughly 16.5 percent of the total U.S. building stock of nonresidential government and privately owned buildings (excluding multifamily buildings)[10].

Portfolio Manager is an operational rating that measures a building's actual performance. It rates buildings on a 1-100 scale relative to the energy efficiency of peer buildings nationwide. Peer building data is derived from the Commercial Building Energy Consumption Survey (CBECS) administered by the U.S. Department of Energy's Energy Information Administration. A "50" on the scale represents median energy efficiency, while a "75" represents a building that performs better than 75 percent of buildings. Portfolio Manager requires several nontechnical data points to derive ratings, including 12 consecutive months of utility bills, which are normalized for factors such as climate and occupancy.

Several U.S. states and local jurisdictions have adopted Portfolio Manager to measure the efficiency of government buildings and/or buildings in the private sector. Portfolio Manager rating mandates are required for private sector buildings in the District of Columbia; the states of California and Washington; and the cities of Austin, Texas, New York and Seattle.

ENERGY STAR target finder. Target Finder is a nonresidential rating tool for new buildings and large renovations administered by EPA ENERGY STAR. It was launched in 2004 and uses the same 1-100 scale and comparison methodologies employed by Portfolio Manager. The Target Finder rating represents estimated energy efficiency (based on inputs from independent energy modeling) rather than measured performance.

ASHRAE Building EQ. The Building EQ is a new labeling scheme for nonresidential buildings developed by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Currently in pilot, Building EQ is comprised of an asset label and an operational label scheduled for release to the market in 2010 and 2011.

Borrowing from the labeling schemes in Europe, Building EQ uses an alphabetical scale from "A" to "G", with "A" being the best rating. The asset rating would draw from inputs from independent energy modeling done on a building, while the operational rating would draw from a building energy audit.

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[9] http://www.energystar.gov/index.cfm?fuseaction=HOME_ENERGY_YARDSTICK.showGetStarted

[10] According to McKinsey & Co., U.S. nonresidential government and privately owned buildings total 78.2 billion square feet (Choi Granade et al. 2009).

Institutional Frameworks for Rating and Labeling

China

Policy. There is no incentive policy, tax policy or fiscal policy that encourages building owners to participate in the MOHURD building energy rating program. Last year, thirty four new buildings applied for building labels, including twenty residential and fourteen non-residential buildings. Twenty buildings eventually received asset rating labels. No building has received an operational rating label.

New government-owned buildings and large non-residential buildings are required to obtain building labels. Buildings applying for the national green building labels are also required to first apply for building energy labels. Neither rule is strictly enforced. Of the twenty-two buildings received green building labels, very few applied for building energy labels.

Assessment. There are two types of building rating institutions in China: national building rating institutions approved by MOHURD, and provincial rating institutions certified by provincial construction commissions. Only national building rating institutions can evaluate applications for three star labels, and provincial institutions can only evaluate one- and two-star labels.

MOHURD divides China into seven administrative regions: Northeast, North, Northwest, Southwest, South, Southeast, and Central South. Each region can have only one national building rating institution. Each province can have up to three provincial building energy rating institutions.

MOHURD re-certifies national building energy rating institutions every three years. A failed institution has up to six months to apply for re-certification. If it fails again, it is not eligible to apply for the next three years.

United States

Policy. The United States has no federal policy requiring building energy rating or labeling. On the state and local levels, several policies require energy rating for commercial buildings.

For residential buildings, HERS ratings are required to demonstrate compliance with federal tax incentives and energy efficient mortgage programs and several voluntary national rating programs (ENERGY STAR, DOE Builders Challenge). A few states and local jurisdictions have enacted policies requiring the posting of HERS ratings in new homes.

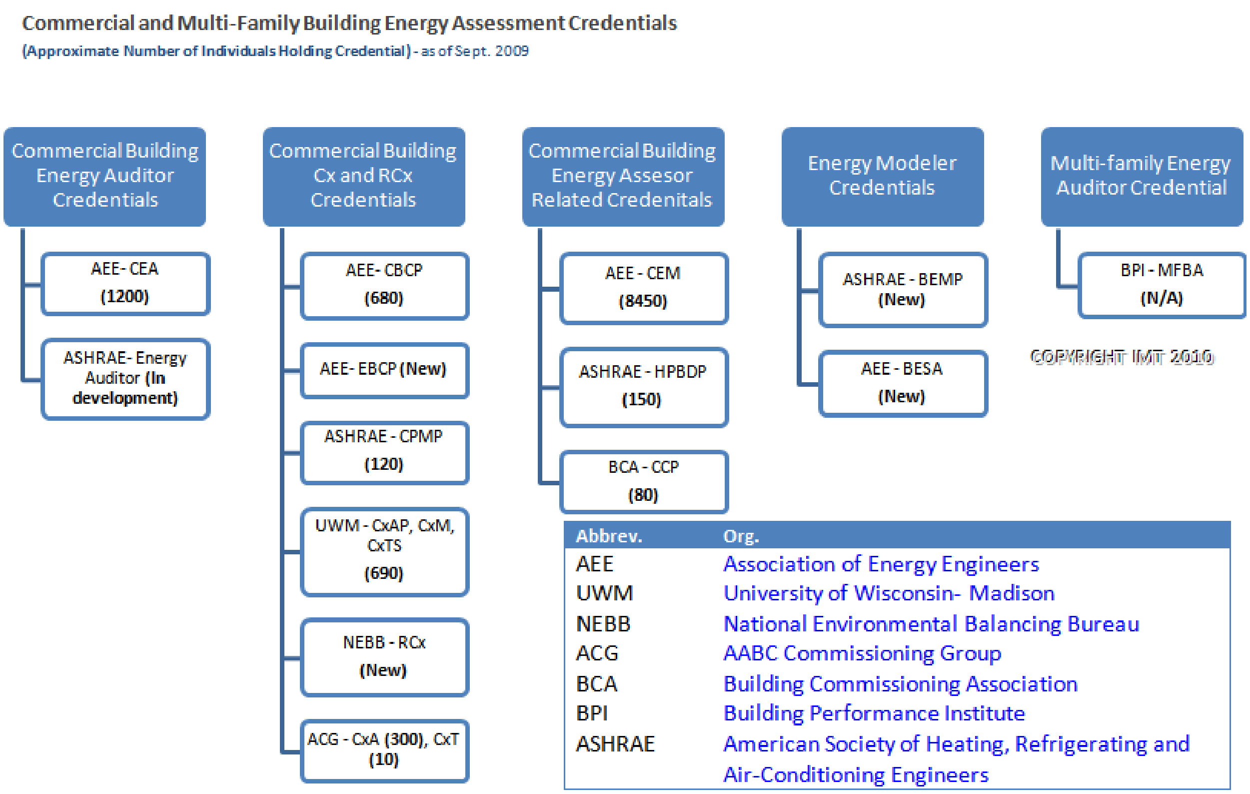
Assessment. U.S. building energy assessment tends to be divided between the residential, multifamily and commercial sectors. The residential sector is dominated by HERS raters and the commercial and multifamily sectors are highly fragmented due to the unorganized state of commercial building rating programs.

Most HERS raters provide support for builders looking to comply with the federal tax credit for new efficient homes, or for homeowners interested in the Energy Efficient Mortgage program. There are HERS raters in every U.S. state; however the number of raters per state varies greatly.

On the commercial side, historical demand for energy rating assessments has been nominal. Professional credentialing programs for energy assessors tend to be voluntary, with few energy-efficiency programs or policies requiring their use. A notable exception is New York City, which requires credentialed professionals to perform energy audits in conjunction with a commercial building energy audit mandate enacted in 2009 (New York City 2009).

Many energy-efficiency programs do require other credentials such as a license as a professional engineer to conduct or approve an energy audit of a commercial building.

Figure 3. Existing Commercial and Multifamily Building Energy Assessment Credentials



Source: Kemkar 2010.

Market Barriers

China

The MOHURD rating and labeling program faces a number of barriers, both technical and institutional, that must be addressed as the development of China's labeling program moves forward.

Capacity building. The building labeling program established by the central government spawns significant capacity-building challenges when MOHURD attempts to expand the program at provincial and municipal levels. MOHURD is reluctant to consider allowing market-based third-party raters to provide rating services, for fear of fraud and lack of capacity. The building rating and labeling program has to rely on limited building experts in a dozen of building rating institutions. Considering that China's annual new construction is about 2 billion square meters–

nearly half of world's new construction – capacity building is a challenge that must be immediately addressed to avoid long-term locked-in inefficiency.

Integration of asset rating and operational rating. It is unclear how the system will integrate asset rating and operational rating. At the current stage, operational value has little impact on the rating level, which may reduce owners' willingness to obtain it given significant higher costs.

Complicated modeling tools. MOHURD designated several modeling tools for building ratings. One complaint is that different simulation tools show significantly different results for the same building. In addition, only a small group of highly experienced building experts know how to use the modeling tools. User-friendly rating software is needed to increase productivity, reduce input errors, remove intentional data manipulations, and, most importantly, build rating capacity.

High charge for rating services. Cost of building energy rating and labeling services is considerably high, costing tens of thousands of yuan. Since most pilot projects are national demonstration projects receiving special incentives, the building rating expenses are covered. The fee charge for rating services is a big issue for voluntary projects that are not eligible for any subsidies.

United States

Market apathy about energy efficiency. Most building owners have never measured the energy efficiency of their buildings and display a general disinterest in improving building performance. There are many reasons for this, including the relatively low cost of energy and a lack of comparative baselines. On the commercial side, split incentives are a significant barrier. On the residential side, there is an assumption that improving energy performance involves living less comfortably. The desire to improve energy performance and save on energy bills is overridden by assumed negative impact on comfort, ignorance to potential financial and comfort benefits, and overestimation of the invasiveness of the process.

Uninformed marketplace. The marketplace is unable to obtain comparative building energy information and value energy efficiency. Prospective commercial tenants, investors, homebuyers and lenders cannot differentiate energy-efficient structures from energy-inefficient structures, inhibiting demand for energy-efficient homes and buildings.

Cost. Commercial building energy audits and deep-building retrofits may be cost-prohibitive to commercial owners, especially owners of smaller buildings. Energy simulations for commercial asset ratings can cost tens of thousands of dollars. For residential, a HERS rating costs an average of $492[11] which is a significant elective expenditure for the average homeowner. This cost is partly a result of the "niche" market currently served and partly a result of required tests, including blower door and duct tests.

Inaccuracy of asset ratings. During the building design process, energy modeling is typically done for code compliance, which has been proven to not necessarily produce realistic predictions on how a building performs during operation. Modeling for codes does not typically account for

[11] http://www.natresnet.org/hotnews/Report_on_Cost_of_Ratings.pdf

unregulated loads. New rules must also be created to the design of reference buildings in energy models to prevent gaming of reference variables to produce favorable results.

Insufficient energy assessor credentialing infrastructure. There is a lack of uniformity among existing programs in terms of content, rigor, process, and cost and insufficient quality assurance and professional accountability, largely because of resource and staffing limitations (Kemkar 2010). Developers of energy-efficiency legislation, mandates and programs in the United States perceive that these existing credentials are not "legal-grade," requiring further checks to ensure accuracy and adding cost and complexity to policy and program implementation. The diversity of commercial building sizes and types and the complexity of commercial energy systems makes it difficult to create a single uniform standard.

Lack of policy signals. More policies on the federal, state and local levels must be enacted to require or encourage commercial and home rating. The United States lacks a comprehensive federal policy governing commercial rating, and rating mandates are found in only a few states and jurisdictions. Building owners and realtors have opposed rating mandates and the development of a building energy label at all levels of government.

Currently, HERS is used by the Energy Star new homes program to qualify for the Energy Efficient Mortgage, and in the Builder's challenge. HERS is also used to document code compliance in 16 states.[12] These programs are all voluntary and have resulted in the wide acceptance of HERS, however more could be done. The Energy Efficient Mortgage is not widely used or known, and its chief benefit – allowing the user to qualify for more financing – is available through other products. Encouraging greater enforcement with possible third-party compliance for energy codes could greatly increase the penetration of energy ratings. Similarly, incorporating energy efficiency into the mortgage underwriting process represents a huge potential opportunity for home energy ratings.

Opportunities for Alignment in Chinese and U.S. Building Labels

A number of practical opportunities exist to align Chinese and U.S. rating and labeling systems.

Increase accuracy of asset ratings. Insufficient rules on aspects of energy modeling compromise aspects of asset rating quality in both nations. On the commercial side, the modeling of Chinese reference buildings rely on limited specifications in building energy standards and largely depends on personal experience, which leaves excess room for interpretation. One solution to this problem could be the Commercial Energy Services Network (COMNET), a set of technical guidelines being developed to address similar commercial asset rating problems in the United States. COMNET would establish more rigorous standards for defining a hypothetical reference building in modeling and provide new guidance on building operation assumptions, non-regulated equipment loads and other inputs. As a result, energy models would more accurately reflect the operation of buildings, thereby increasing the accuracy of model-based asset ratings.

[12] http://www.natresnet.org/about/resnet.htm

Further integration could be possible on the residential side. In the U.S., competing software packages are required to pass physics "stress tests" to become RESNET-certified. The tests currently include the RESNET HVAC test, Duct Distribution System Efficiency Test, the Hot Water Performance test. Additional tests on other performance factors could be developed to determine sufficient modeling accuracy. Open sharing on testing protocols and assumptions could provide immense benefits to both nations' simulation tools.

Integrate asset and operational ratings. Recognizing the individual benefits and limitations of asset ratings and operational ratings, both nations are attempting to integrate asset and operational ratings, although China is arguably closer to achieving this on a broad scale than the United States. Doing so would considerably strengthen any building energy label, positioning it as a complete package of information that addresses designed and measured energy consumption. Asset ratings should inform operational ratings and vice-versa.

Use ratings for code compliance. A major motivation for China to develop its labeling program is to help enforce building codes, although policy and/or incentive support must be greater to increase the chances of success. The same is true in the United States, where poor energy code compliance and enforcement is also a major problem.

Balance accuracy and cost. Both the U.S. and China face the same challenge of balancing rating accuracy and cost. China's non-residential building standard, GB 50189-2005, refers to the old version of ASHRAE Standard 61-2005, and its minimum specifications on ventilation rate and thermal transmittance of building enclosure were decided by simulation analysis using DOE-2. There is a lot of common language between U.S. and Chinese building energy experts to work together to strike the balance of accuracy and cost. The U.S. Department of Energy is currently developing a national framework for home energy labeling where cost and accuracy are two of the most significant challenges.

Communicate building energy rating to the public. For building energy rating and labeling to be most effective, consumers must recognize energy consumption as a critical piece of information in valuing products, including buildings. The U.S. and China can share experiences on public outreach and awareness campaigns.

Address multifamily high-rise buildings. In both nations, energy consumption in multifamily high-rise buildings is of great interest and great concern. Multifamily high-rises dominate China's residential market and comprise a significant share of residential space in major U.S. cities. Because these buildings straddle the line between residential and commercial, energy modeling is more complicated and has progressed slower than with other buildings types.

Conclusion

It is clear that in both the United States and China the importance of building energy rating and labeling is becoming greater. China is developing a national building rating and labeling program through a government agency, MOHURD, while the United States has several rating and labeling systems either deployed to the market or under development.

As expected, there are significant structural and conceptual differences between U.S. and Chinese labeling efforts. China has historically developed most of its rating systems through central and local governments, while the U.S. has relied on the private sector for much of its rating infrastructure. The comprehensive Chinese MOHURD program covers residential and nonresidential buildings and both asset and operational ratings, while these real estate sectors and labeling elements tend to be more fragmented in U.S. rating systems.

Yet, there are also considerable commonalities between U.S. and Chinese rating and opportunities for alignment, as noted in the previous section. Both nations have similar questions that must be answered: How to integrate asset rating and operational rating; how to balance the cost and accuracy of ratings; how to develop more supportive policy frameworks; and how to utilize market forces to expand rating.

It would benefit both the United States and China for building scientists, energy experts and government agencies from each nation to expand on the issues identified in this paper and collaborate on improving building rating and labeling systems.

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