Update on Labeling, Rating, and Benchmarking Efforts in the US and China: How to Increase Collaboration and Effectiveness

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ABSTRACT

The US and China have continued to make progress on the development and implementation of rating and labeling systems that provide information about the environmental attributes, energy use, and energy costs in buildings. Providing this information is key to unlocking markets for energy efficiency and can inform a variety of policy goals, including code enforcement, financing, and encouraging the design and construction of highly-efficient, green buildings. Mo et al. provided the first comparative look at building labeling systems in the US and China in the Proceedings of the ACEEE 2010 Summer Study on Energy Efficiency in Buildings. This paper provides an update on the status of building labeling and rating efforts in each country: including changes or developments to the systems themselves, and their use and implementation. It also identifies remaining technical gaps, barriers to implementation, and next steps, including opportunities for collaboration. This paper provides a brief overview of selected rating and labeling systems in each country, and focuses on progress and development made over the last two years. This paper also describes how building rating systems are currently used, looking at both specific policies that have driven adoption, as well as the reasons for general uptake in the marketplace. The paper also analyzes existing gaps and barriers – both technical and policy-related – to the implementation of rating and labeling systems for buildings in each country, and identifies ways to overcome these barriers, in particular ways in which the US and China can collaborate to to develop and implement pragmatic solutions that address the barriers.

Introduction

Both the US and China have enormous potential to reduce energy use and pollution through energy efficiency improvements in new and existing buildings. For example, the U.S. National Academy of Sciences' study America's Energy Future finds a potential savings in buildings of almost $170 billion a year in 2030 for a cumulative investment cost of $440 billion, which amounts to a rate of return on efficiency investment of more than 30 percent.(NAS 2010) Similarly, analysis by McKinsey & Company found that there were energy savings opportunities in buildings and appliances in China through 2030 equivalent to 300 million tons of coal and 1,000 billion kWh of electricity annually, 70 percent of which was available at negative cost. (McKinsey 2009) Despite the fact that these investments in energy efficiency are cost-effective, they are not being undertaken due to a variety of persistent barriers. Information about building energy efficiency and energy usage and costs is a key ingredient to the proper valuation of energy efficiency in the marketplace and enables the implementation and enforcement of policies to promote energy efficiency in buildings in multiple and mutually reinforcing ways described next.

To address these market failures requires a broad array of interventions across the entire range of market adoption levels including: minimum codes and standards, normative labels, informative labels, short-term managed incentives, long-term incentives and market-directed research and development. *Building labeling and rating*[1] *programs are intimately connected with all phases of these market interventions, in addition to being a form of policy intervention in and on their own.* Building and ratings system can assist at all levels of the spectrum:

- *Building codes*. Building codes ensure a baseline level of energy efficiency in new buildings and major retrofits of existing buildings, but must actually be implemented in order to be effective. Rating and labeling systems can assist in performance based-code compliance by reducing modeling needs and providing understandable documentation to code officials.
- *Normative Labels*. Normative labels give information on whether a product or building meets a minimum performance level but do not necessarily provide specific information on energy use (e.g. ENERGY STAR, LEED, or the Chinese star system). Normative labels are useful for communicating to consumers who do not have in depth knowledge about building energy use, but do not provide enough information for consumers to make a fully informed decision.
- *Informative labels*. If the goal is to make markets work, informative labels, which provide actual information on energy use and cost, are an essential ingredient in making that happen as they allow market decisions to be made on better information.
- *Incentives*. Ratings and labels can be used to evaluate performance and therefore eligibility for energy efficiency incentives.
- *Financing.* Labeling and rating systems allow energy costs to be considered in the financing of buildings, which is currently a key market barrier to the implementation of energy efficiency.

Both the US and China have been working in the area of building energy labels to help address the existing market failures and promote energy efficiency in buildings. While the US and China face somewhat different challenges in addressing the efficiency of their building stocks, there are also many similarities and potential to learn from each other. In the US, the primary challenge will be in retrofitting the existing113 million homes and 4.9 million commercial buildings. (EIA 2009; EIA 2003) In China, the challenge is in both retrofitting existing buildings and in ensuring that new construction is built to high energy efficiency standards, as the total floor space in China is projected to double between 2005 and 2030. (McKinsey 2009) It is therefore critical for policies to address retrofits and to have labeling and rating systems that can be used for both retrofits and new construction.

There is an ongoing effort between the US and China to learn from each others' efforts and collaborate on building energy rating and labeling. In November 2009, President Barack Obama and President Hu Jintao announced the US-China Energy Efficiency Action Plan which aimed to improve the economy, energy security and combat climate change through joint efforts to reduce wasted energy in each country. One of the action items of this plan was to increase green buildings and sustainable communities through "building codes and labels, training building inspectors and developing advanced energy rating systems." (White House 2009) Also in November 2009, both presidents announced the establishment of the US-China Clean Energy

[1] In this paper, the term rating is used to describe the process for measuring and stating an energy figure of merit and the term labeling to describe the display, branding, disclosure, or dissemination of information on the building's efficiency including the value of a building's rating.

Research Center (CERC) for US and Chinese experts to collaborate on research and development on a variety of clean energy initiatives, including the area of building energy efficiency. In 2010, the Natural Resources Defense Council, the Chinese Ministry of Housing and Urban-rural Development (MoHURD), and the Institute for Market transformation published the first comparative report on China and US labeling and rating systems. (Mo et al 2010) As part of the US-China CERC initiative, NRDC, the National Association of State Energy Officials (NASEO), and MoHURD have continued to conduct research on and compare US and Chinese building energy efficiency rating and labeling systems.

This paper is a result of that collaboration and will describe the progress made in the US and China on building energy labeling and rating systems over the past few years, including updates to systems, pilot programs, new systems under development and updated information on the use of systems, where available. It will also provide an update on the barriers identified in the Mo et al paper and identify potential areas of collaboration.

China's Building Energy Efficiency Rating System

Description of System

The Chinese rating system has not changed in substance since it was first established in 2008, but modifications are currently being contemplated based on the results that have been obtained from the pilot projects. As described in Mo et al, China has a single rating system that encompasses both an asset and operational rating for all building types which was established in 2008 based on the *Technical Guidelines for Energy Efficiency Labeling for Civil Buildings* (Trial Implementation) (BS [2008] No. 118). These guidelines specify both the details of the rating system and the requirement that new government office buildings and large public buildings (which include office buildings, malls, and other building types over 20,000 square meters) obtain a rating. The Chinese rating system uses a normative label which has a scale of one to five stars to indicate the energy efficiency level of the building, but also includes specific energy use information. The number of stars achieved by a building is based on percent reduction in heat loss through the building envelope compared to the baseline code building which requires a minimum 50 percent reduction in heat loss, as shown in Figure 1. In order to be rated, a building must also meet prescriptive requirements with regard to the buildings structure, thermal comfort, and HVAC system efficiency. Optional items, such as innovative design or renewable energy can also be added to increase the star rating. (Mo et al; Liu Shan 2011)

In order to obtain the building energy efficiency label, the asset rating[2] is first calculated by the building designer, who must meet certain professional qualifications. A third-party government-approved institution (either a national or provincial assessment institution) then verifies this information both by evaluating the building model and auditing the building as constructed, including document review, on-site inspection and performance testing. It is this third-party institution that gives final approval of the label for publication. This asset rating determines the overall star level achieved by the building and is valid for one year after the

[2] An asset rating compares the energy use of different buildings assuming operation is identical. Since identical conditions are nearly impossible to achieve in the field, asset ratings are based on simulation. Simulations based on carefully chosen assumptions generally are within 3% of measurements for a large sample of buildings.

building is occupied. Once occupied, the owner is supposed to get an operational rating[3], which is valid for 5 years. The operational rating is based on metered electricity data from the power provider (it is very difficult to get data on actual heating energy use, so this is not included) and is not weather-normalized. The operational rating does not change the star rating of the building. (Liu Richard 2012)

Figure 1. China's Building Energy Efficiency Star Rating System

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: Mo et al. 2010

Update on Implementation

The Chinese building energy efficiency rating system has been in a pilot phase for the last three years. New buildings with public financing (including government buildings and large civil buildings) and demonstration green buildings are required to participate in the pilot and other buildings can participate on a voluntary basis. 200 pilot projects have been completed to date in 4 of the 5 Chinese climate zones (all besides the mild zone).[4]

MoHURD recently published a paper summarizing findings from the first phase of the pilot, during which 82 buildings received the building energy efficiency ratings. Of the buildings rated, the majority achieved either one or two stars (35 buildings and 34 buildings respectively), while 13 buildings achieved the 3 star rating. (Liu Shan 2012) Buildings that achieved one and two stars ratings were fairly evenly split between residential and public buildings, whereas most of the three star ratings were for residential buildings. (Ibid) Additionally, modeled energy use per square meter was found to vary for both building types. In fact, although overall largely variable, there was a slight upward trend in the modeled energy use per square meter for public buildings as the number of stars increased despite the fact that these buildings had generally achieved a higher percentage of energy savings. For residential buildings the number of stars achieved in the rating tended to reflect decreasing energy use. (Ibid) The study also found that projected heating and cooling energy use was the higher by a factor of two in the severe cold climate zone (85.2 kWh/m^2 per year) and lowest in the cold climate zone (29.01 kWh/m^2). (Ibid) Since the first phase of the pilot, there have been 5 rounds and over 200 pilot projects conducted in over 20 provinces, both in the pilot cities and in other locations, primarily on a voluntary basis. Of these pilots, 165 buildings have received an energy efficiency rating: 22 have

[3] An operational rating is based on metered energy use. Often the raw metered data is normalized for relevant variables such as weather, operating hours, occupant count, etc., but this is not the case in China.

[4] Initially, pilot cities were listed in the *Interim Measures of the Labeling System for Evaluating Energy Efficiency of Civil Buildings, Interim Measures for Agencies for Evaluating Energy Efficiency of Civil Buildings (BS [2008] No. 80)*, which was issued in April 2008, but in the second half of 2008, the State Council issued the *Energy Conservation Regulations for Civil Buildings (The State Council's Decree of The People's Republic of China, No. 530)*, which allowed for ratings to be conducted for buildings outside of the pilot cities as well, mostly on a voluntary basis. (Liu Richard 2012)

achieved the three star level, 58 the two star level, and 85 the one star level. These pilot projects have been fairly evenly split between public and residential buildings, with 88 and 77 buildings rated respectively. (Liu Richard 2012) There are still no projects that have received a four or five star rating and, consequently, MoHURD is contemplating modifying the system to a three star system. (Liu Shan 2011) The pilot projects have included both new construction projects and building efficiency retrofits and have almost exclusively been asset ratings. To date, only one building has obtained the operational label. (Liu Richard 2012)

The primary driver for rating and labeling buildings in China is the government requirement that certain new building types receive a rating. However, this mandate is still not uniformly complied with. Additionally, there is a requirement that the building efficiency rating be used as a prerequisite for the green building rating, but this requirement is not frequently enforced. Part of the issue is there is a disconnect in timing as the green building rating can be issued during design, whereas the building energy efficiency rating cannot be issued until construction is complete.

US Residential Rating Systems

US ratings systems are generally divided into residential, which covers single family homes and small multifamily buildings, and commercial which covers all non-residential rating systems. For residential buildings in the US there are several existing rating and labeling systems including the Home Energy Rating System (HERS), Home Energy Yardstick, Home Energy Score, ENERGY STAR, and the EarthAdvantage Institute's Energy Performance Score (EPS). There has been significant activity and progress made over the last several years on residential rating systems in the US, such as the increased uptake of the HERS rating for new single family homes and the development of the DOE's Home Energy Score system, which are both described in this section.

HERS Rating System

Description. The HERS rating system is an asset rating system governed by the Residential Energy Services Network's (RESNET) National Home Energy Rating Standards first adopted in 2002. (RESNET 2012) These standards cover all aspects of an energy rating: inspection guidelines, default assumptions, acceptable rating software, and other technical issues as well as quality control and assurance of raters. The HERS rating contains several types of information, the most prominent of which is the "HERS index," a rating on a scale from zero to 100 and beyond, where 100 represents the International Energy Conservation Code (IECC) 2004 model code and zero represents a zero energy home. A typical existing home is commonly believed to have a rating of about 130, although no data support this (or any other) estimate: no research has yet identified a statistically valid sample of existing homes that have been rated. The HERS rating is independent of house size in the sense that a large home that meets the IECC reference code will score 100, just as a very small home that meets the same code will. The HERS rating also estimates absolute energy use by fuel type, and estimates annual energy operational costs based on these energy values and the cost of fuels.

Update on implementation. The use of the HERS rating is entirely voluntary, but it is used as a compliance mechanism for several policy tools, including the new energy efficiency homes tax credit (26 USC 45L), the ENERGY STAR new home label, and the DOE Builders Challenge. The section 45L tax credit rewards builders with a $2000 tax credit for homes that reduce heating and cooling energy use by 50 percent compared to the 2004 IECC. The ENERGY STAR label, which is awarded to homes that are 20-30 percent more efficient than the typical code built home and meet certain criteria, uses the HERS rating as the compliance mechanism for its performance path. The DOE Builders Challenge designation is awarded to homes that achieve a 70 or better on the HERS scale in addition to meeting other criteria (these criteria are being revised for buildings permitted April 1, 2012 and will require, among other things, a more stringent HERS score). These policy drivers, in addition to market forces, have driven an increased use of the HERS rating over the last several years, in particular for new homes. In 2010 and 2011 each, 120,000 new homes were rated, *which amounted to close to 40 percent of new homes sold in 2011* (Baden 2012; Census 2012). Both the overall number and percentage of new homes rated has been growing, despite an overall drop in new home construction in the US, as shown in Figure 2. Similarly, the total number and percentage of tax credit verified homes has grown steadily since the year the credit was enacted, from close to 0 to over 10 percent (note the tax credit expired at the end of 2009 and was only extended retroactively for 2010 which led to the dip in numbers that year).

Additionally, an increasing number of builders have signed memoranda of understand (MOUs) with RESNET to rate all of their new homes. By the end of 2011, the ten largest production home builders in the US and over a hundred local and state builders had signed MOUs with RESNET to rate all of their new homes using the HERS Index. (RESNET 2011)

Figure 2. Total Number and Percentage of New Homes Rated with HERS Index and Number of Homes Verified for the Tax Credits from 2006 to 2011

Year	Number of Homes Rated with HERS Index	% of New Homes Sold Rated	Number of Homes Verified as Eligible for Tax Credit	% of New Homes Sold Verified for Tax Credit
2006	N/A	N/A	7,110	0.7%
2007	N/A	N/A	23,000	3%
2008	100,000	21%	22,000	5%
2009	116,000	31%	37,000	10%
2010	120,000	38%	21,000	7%
2011	120,000	40%	32,000	11%

Source: Baden 2012

The increase in both the percentage of new homes receiving a HERS rating and the number of builders who have signed MOUs with RESNET is significant. This increase has been driven by many factors, notably the tax credit, the use of the HERS system for the normative ENERGY STAR label and Builders Challenge, and the overall downturn in the US housing market, in which builders have found they can distinguish themselves by marketing the energy efficiency of their homes, as evidenced by the number of builders that have signed MOUs with RESNET.

Home Energy Score

Description. In 2010, DOE initiated a program to create a new asset rating system for new and existing homes, known as Home Energy Score. The idea behind the creation of Home Energy Score was to create a rating that was cheaper and easier to use than other existing systems so that it would be more widely deployed and encourage retrofits.[5] The concern with this approach is that simplicity and low cost would be traded for accuracy of the score.

The Home Energy Score is based on approximately 40 pieces of collected data about the home, including year built, conditioned square footage, number of bedrooms, orientation, insulation levels in walls, foundation, and attic, exterior finishes and construction (walls and roof), attic type, window area and efficiency, HVAC and hot water system year of installation and efficiency, and envelope and duct leakage (measured or estimated). (DOE 2012a) The score is on a one to ten integer bin scale – ten being most efficient. In addition to the numerical score, the HES report also includes the estimated total annual energy use in MBTU, recommended improvement measures, and potential score increase and dollar savings with these improvements. (Ibid)

Implementation. In 2011, DOE ran a pilot program to test its Home Energy Scoring Tool in the states of PA, MA, IL, VA, IN, OR, SC, TX, MN, and UT in which over 1000 homes were scored. The purpose of the pilot was to test whether they were collecting the right data, whether the bin distribution was correct, how assessors and home owners reacted to the tool, whether diagnostic tests affected the result of the tool, and the accuracy of recommendations. DOE found that in general they were collecting the right information and has since refined the Home Energy Score Tool based on input and feedback from the pilot and is currently in the process of identifying partners (state and local government organizations, utilities, nonprofits, etc) for the national launch of the tool in 2012. (DOE 2011)

US Commercial Rating Systems

In contrast to the residential rating systems, which are all asset ratings, there is one widely used rating system for commercial buildings in the US based on operation, ENERGY STAR Portfolio Manager, and several asset rating systems currently in different stages of development. The Commercial Energy Services Network (COMNET) has developed modelling guidance which was finalized last year and which could be used within a rating system or for compliance with other policy tools such as the energy efficient commercial buildings tax deduction.

ENERGY STAR Portfolio Manager.

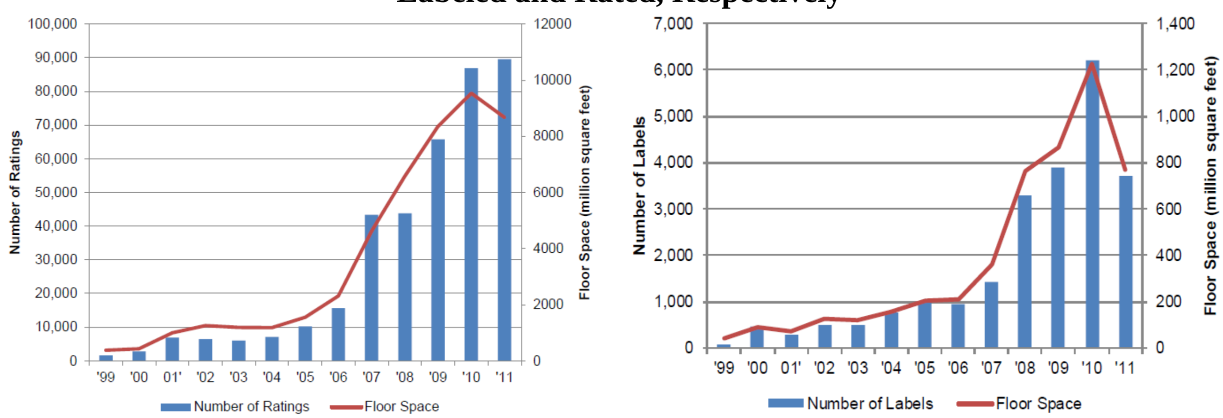
Description. The ENERGY STAR Portfolio Manager system is an operational rating tool for commercial buildings. Portfolio Manager uses energy bill data to generate a score from 0 to 100 which represents the percentile ranking of the building for a given year compared to the 2003 Commercial Building Energy Consumption Survey (CBECS) database, normalized for variables such as weather, building type, size, and occupancy. Any building can benchmark using

[5] There is little data that we are aware of to date to support the hypothesis that home energy audits and ratings on their own drive retrofits.

Portfolio Manager but only certain building types are eligible to receive an Energy Star score. In order to earn the ENERGY STAR label a building must be in the top 25th percentile of buildings compared to the 2003 CBECS data for a given year.

Implementation. As shown in Figures 3 and 4, both the total square footage rated and that achieving the ENERGY STAR label annually has grown significantly over the past 5 years. This is due to several factors. The first is that Portfolio Manager is relatively easy to use (it does not require modelling, on-site data gathering, or in-depth knowledge of building science) as it only requires the input of utility bill data and other basic building information. Consequently, many large building owners and managers have become familiar with the tool. Furthermore, building owners and managers can market buildings that have achieved the ENERGY STAR label and limited research has found that green buildings earn a premium in the market and have higher occupancy rates. For example, a 2008 study by the CoStar Group found that ENERGY STAR rated buildings garnered $25.80 additional rent per square meter with a 3.6 percent higher occupancy rate. (Miller et al. 2008) However, a more recent study found that while LEED still garnered a premium, ENERGY STAR buildings were more in line with the rest of the market. (Miller and VP Analytics 2010) While further research is needed in this area, this could indicate the effect the market downturn has had in driving the industry to look for ways to distinguish their buildings, coupled with a growing awareness and demand for energy efficient and green buildings in the commercial real estate market. The 2008 study found that ENERGY STAR and LEED buildings also sold for an average of $656 per square meter and $1840 per square meter more than equivalent buildings, respectively. (Miller et al. 2008)

Figures 3 and 4. Annual Number and Square Footage of Commercial Buildings Labeled and Rated, Respectively



Source: EPA 2011

An additional driver of the use of Portfolio Manager has been the requirement for Federal agencies to lease Energy Star labeled buildings (with some exceptions), which took effect in December 2010. Additionally, five cities and two states in the US have adopted local benchmarking and disclosure requirements for commercial and multifamily buildings within the last five years which has both been facilitated by the fact that building owners are familiar with Portfolio Manager and will help contribute to further adoption. The size and type of effected buildings as well as who and when the information must be disclosed to varies, as does the timing, but all go into effect within the next five years. These current policies could affect more than 60,000 buildings and an estimated 4.1 billion square feet. (IMT 2011)

Several asset rating and combined systems under development. While there is no existing widely-deployed asset rating for commercial buildings in the US, there are several in different stages of development

MA commercial asset rating program. The state of Massachusetts is in the process of piloting an asset rating program. In December of 2010, the MA Department of Energy Resources (DOER) in conjunction with the National Governors Association Policy Academy on Building Retrofits developed a white paper outlining its plan for a commercial building asset rating pilot program. (MA DOER 2010) DOER received many public comments on the white paper supporting the need for an asset rating system and also the need for inexpensive energy assessments. In December, 2011, the nonprofit regional efficiency group Northeast Energy Efficiency Partnerships (NEEP) issued a request for proposals (RFP) in conjunction with MA DOER on innovative, less expensive methodologies for assessing and calculating a commercial building's as built energy efficiency. Three projects have been selected under the RFP, which will be conducted during 2012 in the Boston Area. In phase one of the pilot, DOER and NEEP will compare the innovative assessment methods to standard in depth methods to assess accuracy, repeatability and ability to predict energy use. From the first phase of the pilot, they plan to select the most promising methodology or –gies that they will than test in the fall of 2012 on a larger set of commercial office buildings in eastern Massachusetts. (NEEP 2011)

ASHRAE Building EQ. The ASHRAE Building Energy Quotient (bEQ) is another recently developed rating system, which was piloted in 2009 and 2010 and was recently launched. The ASHRAE bEQ system can combine an "as-designed" asset rating with an "in operation" operational rating, as appropriate. The label for ASHRAE bEQ uses a normative letter grade scale. The rating is designed for both new and existing buildings. For the "as-designed" rating, a building is modeled in comparison to ASHRAE 90.1 and 189.1. The "in operation" rating must be conducted by an ASHRAE certified energy assessor. As of the time of writing, only the "in operation" rating was available to the general public. The cost of the ASHRAE bEQ rating is $500 to ASHRAE plus the cost of assessment and modeling. (BuildingEQ 2012)

DOE commercial asset rating tool. DOE issued a request for information in the fall of 2011 on its plan to develop an asset rating program. While the DOE program tool is still in the pilot stage it will consist of an asset rating system that will convey a commercial building's as built energy performance and a free online asset rating tool that will allow owners and operators to assess their building's efficiency, recommend efficiency measures, and produce an asset rating. DOE is considering have such a tool be tiered so that both building owners and operators could use it with limited information to produce initial assessments and recommendations and qualified professionals could also use it to produce verified rating. DOE is currently soliciting partners for its pilot which it plans to launch later this year. (DOE 2012b)

Development of COMNET guidance. Over the past decade, the many participants in the building efficiency non-profit community in North America have recognized the need for a nationally-consistent (or, better, globally-consistent) asset rating system for commercial buildings. This was evident by the fact that the US had (and still has) a number of different programs that were at risk of trying to do the same thing in different ways, including the ASHRAE system for demonstrating performance-based compliance to ASHRAE 90.1 (and more recently for labeling buildings through ASHRAE BEQ), the USGBC's LEED system that assigns points for improvements in energy efficiency beyond code, the ENERGY STAR Target Finder program, the Section 179D tax deduction, state programs such as the MA iniative described above and California's Title 24 energy code compliance, and numerous utility-sponsored programs that based incentives on percent savings beyond code. Increasingly, percent savings beyond code has become a marketing tool for building owners and developers, so there is a need for uniformity in how this is calculated. The result was the development of the COMNET system in 2009.

The COMNET Modeling Guidelines & Procedures contain specifications for how to build and use software that can meet three purposes in a standardized way: 1) eligibility for the section 179D commercial building tax deduction; 2) calculating percent savings from code for green building system points; and 3) estimating energy use during the design phase of a building to be used in an energy label. The modeling guidelines contain detailed information on how to establish the baseline building, operational assumptions (e.g. thermostat settings, occupancy, miscellaneous loads, HVAC schedule, lighting, etc), standardization of how to calculate percent savings (which can vary depending on whether the baseline includes total energy use or just regulated energy), requirements for software modeling engines, standardized report formats, acceptable modeling input ranges, and energy cost data.

At the time of writing, there is not any COMNET-compliant software available, so the system cannot, in practice, be used. However, more than one software company has indicated that it plans to seek COMNET accreditation for its software by early 2012.

Barriers, Needs, and Potential for Collaboration

There are several shortcomings of the existing labeling and rating systems in the US and China, barriers to further implementation and needs for further coordination, updating and development. Mo et al identified many barriers to the proliferation of labeling and rating systems in both countries, many of which persist.

In China, the limited capacity to rate buildings, integration of the asset rating and operational rating, varied simulation results, and cost of obtaining the rating were all identified as barriers to the uptake of the Chinese building efficiency rating system. (Mo et al. 2010) While some progress has been made, all of these barriers still exist. One area of progress is on the varied result for different rating software. Tsinghua University and the Chinese Center for Advanced Building Research (CABR) have been collaborating and comparing different simulation software packages in an attempt to standardize inputs and reduce variation, but this work is still ongoing. And even if successful, it will not produce convergence of asset ratings on a per-square-meter basis because the variation is driven by fundamental characteristics of buildings. Limited progress has been made on how to integrate the asset rating and the operational rating, as only one building has obtained the operational rating so far. Additional barriers to the widespread implementation of the Chinese building energy efficiency rating include a lack of consumer awareness and market demand for energy efficiency ratings[6]. Currently the only driving force of the rating system is the government requirement that certain building types get rated, which is not enough to encourage widespread deployment of the system.

In the US, market apathy towards building efficiency, the cost of ratings, a deficient understanding of the reasons for differences between the asset rating of a given building and its measured performance, and a lack of policy signals were all identified as barriers to the implementation of rating systems. (Ibid) Similar to China, while there has been progress in specific areas, none of these barriers have been entirely overcome. For instance, clear policy signals in the new homes market have led to the widespread use of the HERS rating, but ratings are still not widely used for existing homes, and balancing cost with accuracy is a common barrier in the existing homes market. Conversely, there are some state and local policy signals in the commercial market, but these are sporadic and not uniform across the US. Portfolio Manager has been widely used for operational ratings of commercial buildings, but it has its limitations, including that its baseline data is 10 years old and that it doesn't distinguish between the very top performers or encourage improvements in the worst performing buildings. While EIA is beginning the process of updating the CBECS database, it will be at least a couple of years until that data is available. While there has been much work in the commercial asset rating space in the US by MA DOER, ASHRAE bEQ, DOE and COMNET, there is the potential for dissonance and these players must collaborate going forward to ensure that *complementary, rather than competing systems* are developed to avoid market confusion.

Several issues stand out that are common to rating systems in both countries where further collaboration could be useful. Researchers and policy experts in the US and China should focus on these issues going forward as they continue to collaborate on building energy ratings, such as through the US-China CERC project. These include:

- *Driving market uptake of ratings.* Neither the US or China has seen widespread market demand for building energy ratings. While the US has had some success driving demand in the new homes market through policy tools like the 45L tax credit, ENERGY Star, and the DOE Builders Challenge which has facilitated general market uptake for new homes, uptake in the existing homes market is still low. China's demand is driven by the government requirement for certain building types, rather than by market forces. This is consistent with experience in other regions, such as the European Union, which have tried to implement ratings. Further collaboration on policies and other mechanisms to increase use and consumer familiarity with ratings both between the US and China, as well as other regions, be useful.
- *Integrating building finance with labelling.* Energy use in an average home in the US costs more than half as much as repaying the median mortgage, and in US commercial buildings, energy use accounts for 20 percent of Net Operating Income. These proportions are likely even higher in China. Yet these costs are not often considered in evaluating the creditworthiness of potential buyers or the risks that their loans impose on lenders, nor are energy costs often considered in appraisals. Reforming these practices in both countries could lead to widespread use of ratings.
- *Commercial building operational ratings*. The US and China could collaborate on the development of operational ratings for commercial buildings. The EPA's Portfolio

[6] This barrier is not surprising, since a variety of market actors need to be interested in labels for them to be deployed.

Manager has been quite successful, despite shortcomings described above, while the Chinese operational system has not been used except for in one instance.

- *Modeling*. In both the US and China, consistency across different software packages and the relationship between asset ratings and operational energy use have been persistent issues. COMNET has developed modeling guidance and CABR and Tsinghua University are working on reducing variance in results between different software tools. Note that these are separate tasks: the former is based primarily on *standardizing the assumptions that are input to simulation engines* while the latter is based exclusively on the accuracy of the simulation engine assuming identical inputs. Further collaboration between these and other parties would likely be useful in developing consistency across asset ratings for commercial buildings. Specifically, detailed analysis of which portions of the COMNET modelling guidelines are applicable to China and translation to Chinese would be a useful next step.
- *Driving down costs of ratings*. The cost of ratings, especially the cost of modeling, has been a persistent barrier to the wide use of ratings in both countries. Note that in the US, the cost associated with simulations is almost entirely a consequence of the time needed to measure and input the characteristics of the building, while the actual simulation exercise is quite cheap. Automated tools for inputting variable such as takeoffs (for example, the geometry of the building) might cut inspection and input costs dramatically. While there is some work being done to find ways to bring down these costs (e.g. by MA DOER, COMNET), the US and China should coordinate on these tasks and share lessons learned in these efforts.

Conclusions

There has been significant progress in both the US and China over the past several years on the development and deployment of energy efficiency rating and labeling systems for buildings. In China, over 165 buildings out of over 200 pilot projects have achieved building energy efficiency labels. In the US, there has been an increased use of the HERS Index for new homes, as well as the development of the DOE Home Energy Score asset rating tool, which is being launched this year. On the commercial side, use of Portfolio Manager has increased, several cities have adopted benchmarking and disclosure requirements, the COMNET modeling guidelines have been developed and compliant software will likely be introduced this year, and several commercial building asset rating tools are in various stages of development, including ASHRAE bEQ, the DOE asset rating tool, and the MA DOER asset rating.

Despite all of this progress, there is still substantial work to be done on building energy efficiency labeling and rating in both countries. Specifically, both countries are faced with the challenges of encouraging widespread use and deployment of building efficiency labels in the market, integrating operational ratings with asset ratings, having consistent modeling for commercial buildings asset ratings, and bringing down costs associated with obtaining ratings. In all of these areas, U.S. and Chinese experts and policymakers would benefit from further examination and collaboration, on both policy-related and building science issues. This collaboration is already occurring through the US-China Clean Energy Research Center (CERC) project and likely elsewhere. Direct interaction between experts is a key aspect to this knowledge-sharing, and it should continue to be facilitated through research programs such as CERC. While there are many barriers to direct collaboration between U.S. and Chinese building efficiency experts, the areas identified above could greatly benefit from further examination and exchange between the two countries, and increased collaboration can generate significant benefits for both countries by encouraging increased efficiency in their building sectors.

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