# Transparency for China's Windows through Energy Labeling

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## ABSTRACT

China's construction boom is unprecedented in history, and the market for windows is larger in China than anywhere else in the world. In 2008, the journal *Xiaofei Ribao* ("Consumption Daily") estimated Chinese demand for windows and doors to be 500 to 600 million $m^2$ annually over the next ten years (Abele 2008).[1] Whether this demand is met with energy-efficient or conventional windows will make a dramatic difference regarding heating and cooling energy consumption. Chinese experts and policy makers recognize this and have included window energy performance requirements in national, regional and local design standards. In the case of windows, however, these standards and other market transformation policies require a reliable energy rating system in order to be effective – a system that establishes standardized procedures and a transparent rating process with independent oversight while enabling easy specification and inspection of window energy properties. China is currently pilot-testing a window energy labeling program for this purpose. If successful, this program will not only help address a vast energy-efficiency challenge, it will also be the first example of such a windows labeling program being implemented in the developing world.

## Introduction: China's Window Energy Efficiency Challenge

In July 2009, the Research Institute of Standards and Norms (RISN) of the Ministry of Housing and Urban/Rural Development (MOHURD) kicked off pilot implementation of a windows energy labeling program in two Chinese cities and two provinces. The purpose of this program is to provide building officials, architects, purchasers and the general public with reliable information on the energy performance characteristics of windows that are rated through this new program. Based on the experience from local pilot implementation, RISN is planning for rolling out the windows labeling program nationwide.

The need for windows energy labeling in China is relatively recent. Up until the end of the 1990s, a window was energy efficient if it had two panes (double glazing). The use of double-pane windows in the colder regions significantly improved heat retention. In warmer regions, single glazing was still the norm (Richerzhagen et al. 2008).[2] This was a straightforward situation: energy-efficient windows were primarily for cold climates and could be easily distinguished by the number of panes. Over the past decade, however, the evolution of China's windows market and buildings sector has added opportunities as well as complexity. In 2001, low-e coated glass was introduced in China (ResearchInChina 2009). Low-e coatings further

[1] For comparison, 2007 window usage in the United States is estimated to have amounted to about 50 million $m^2$ in the nonresidential sector and about 60 million windows in the residential sector (DOE 2009). This adds up to about 120 million $m^2$ total annual window usage if average residential windows are assumed to measure 1.2 $m^2$.
[2] In 1999, the estimated share of single-pane windows in the residential building stock was 68 percent in Beijing and 98 percent in Shanghai (Richerzhagen et al. 2008).

improve the insulating value of double glazing and, importantly, can be designed to reflect solar heat. Moreover, newer frame designs with improved thermal breaks or non-metal materials result in reduced frame conductivity. Thus, today's windows can be manufactured to addresses both heat loss in cold climates and the rising cooling energy use in regions with hot summers. These improvements have boosted the potential of China's windows market to meet the energy efficiency demands of the ever growing buildings sector. Yet, the new window energy efficiency options have complicated the task of determining how a window performs and verifying that specifications are met. This is where window energy labeling can help provide reliable information.

**Market status of efficient window technologies**

Many Chinese window and glass companies can now produce technologically advanced products that would meet Western energy efficiency standards, partly by integrating international production machinery and expertise. Technologies such as low-e glazing, low-conductance frames and warm-edge spacers are increasingly popular and could become mainstream window components if more manufacturers invest in the required production capabilities. Low-e glazing is probably the most promising example due to its ability to address both heat loss and solar heat gain. If produced in volume, low-e glazing is generally considered a cost-effective option that, in addition to energy cost savings, can potentially reduce peak space conditioning demand enough so that smaller and cheaper mechanical equipment is sufficient.[3] In 2009, about ten percent of new windows were equipped with low-e glazing (RISN 2010). Although amounting to about 50 million $m^2$ of low-e windows (ResearchInChina 2009), this market share is still low compared to North America, where the majority of new windows has low-e glazing (DOE 2008), or compared to Northern Europe, where the market has almost completely transitioned to low-e (Grönegräs 2008).[4] The success of low-e in these major markets indicates that it is widely regarded as cost-effective and remains a largely untapped opportunity for the Chinese market.

If low-e glazing is combined with low-conductance and airtight frame design, the thermal transmittance of windows can be reduced by well over 1.0 $W/(m^2 \cdot K)$ compared to conventional windows.[5] With 500 to 600 million $m^2$ of windows installed in China each year (Abele 2008), an improvement of 1.0 $W/(m^2 \cdot K)$ would indeed be dramatic if achieved at scale. How fast can the market for energy-efficient windows be scaled up? The improvements over the past decades have been impressive, but the majority of windows remain far behind the potential that is feasible with available technologies. Cost is certainly a barrier, particularly if new production equipment is required for using these technologies. The pace of market transformation to energy-efficient windows thus depends on the success of building energy standards and on whether energy efficiency joins first cost reduction as a priority in purchasing decisions. The windows

[3] According to the U.S. Department of Energy's *Energy Savers* website, the typical cost increment of windows with low-e glazing over regular windows is about 10-15 percent (DOE 2009b). The cost increment may currently be higher in China with its lower market share of low-e glazing. Even so, the potential for sufficient load reduction to downsize heating and cooling equipment may partly offset the initial cost increment.

[4] While among residential windows in the United States, the share of low-e has been above 50 percent for several years, the estimated 2007 share of low-e among nonresidential windows was 48 percent (DOE 2009a). The estimated market penetration of low-e in Northern Europe applies to Austria, Germany, Sweden and Switzerland.

[5] The Efficient Windows Collaborative shows U-values for generic dual-glazed aluminum windows that vary between 0.76 $Btu/(ft^2 \cdot °F)$ and 0.47 $Btu/(ft^2 \cdot °F)$ depending on whether thermal breaks and low-e coatings are used or not (EWC 2010). The metric equivalent would be a range from 4.3 $W/(m^2 \cdot K)$ to 2.7 $W/(m^2 \cdot K)$.

energy labeling program piloted in China is intended to build a basis for both better energy standards compliance and greater end-user demand for energy efficiency. Even a partial success would have great energy savings potential.

### Energy savings potential

Quantitative English-language estimates of the savings potential from energy-efficient windows are more readily available for the United States, but some of their conclusions may be applicable to China as well – at least in the nonresidential sector, where building types are not as fundamentally different between the two countries as in the residential sector. Lawrence Berkeley National Laboratory (LBNL) estimates that if the market share of low-e windows in the United States was increased to 100 percent, savings across the nonresidential sector would average 9-12 percent of heating and cooling energy (Arasteh et al. 2006). In China, where business-as-usual window performance is weaker than in the United States, energy savings from a complete switch to low-e windows can thus be expected to save more than 10 percent of heating and cooling energy. The opportunities for the application of energy-efficient windows lie mainly in new construction. China's 11$^{th}$ Five Year Plan expects nonresidential floor space growth of 5 percent per year through 2020 (Bressand et al. 2007). If energy-efficient windows can help avoid more than ten percent of the associated increase in heating and cooling demand, the difference in the overall nonresidential heating and cooling energy use will reach several percentage points within a decade. This scenario assumes the use of existing technologies that are already available and can be widely adopted. For this to happen, policy signals and the demand for energy-efficient windows must be compelling enough so that manufacturers invest in the required production equipment and expertise.

## Current Policies and Demand for Window Energy Efficiency

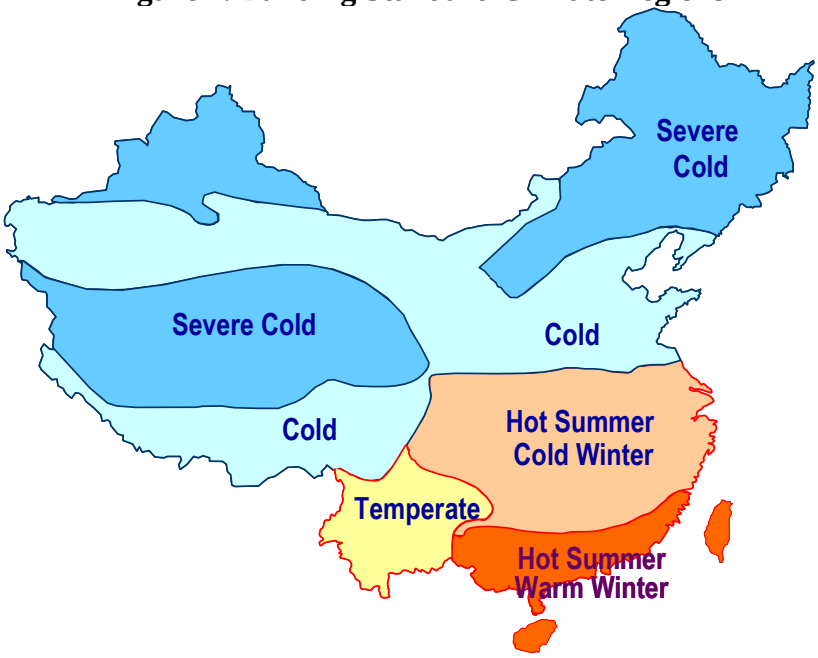
The windows energy labeling program, still awaiting full implementation, is intended to provide officials, professionals and the general public with reliable information on window energy properties. Until this program becomes effective, the demand for energy-efficiency among Chinese policymakers and the wider public does not yet seamlessly translate into the supply and use of energy-efficient windows. Nevertheless, building energy standards and increased public appreciation of higher-quality building components are indispensible in setting the stage for possible window market transformation.

### Building energy standards

All residential and non-residential construction in China is covered by building energy standards that include prescriptive energy performance requirements for windows. These requirements vary by climate region depending on the relative importance of heating and cooling energy demand. The major climate regions are shown in Figure 1. As energy-efficiency benchmarks, these standards have great market transformation potential. Trade-off options between envelope components and the energy budget compliance path for nonresidential buildings allow for flexibility, but overall the prescriptive window requirements encourage the use of energy-efficient windows. For instance, residential window requirements in large parts of the Cold and Severe Cold climate regions call for thermal transmittance values of 2.8 W/($m^2$·K)

or better, which may require the use of low-conductance frames and/or low-e glazing. In climate regions with hot summers, shading coefficient requirements call for the use of tinted or low-e glazing unless window areas are small or shaded. The exact window requirements for thermal transmission as well as shading coefficient vary by sub-region within the larger climate regions and by the ratio of window area to wall area (Shui et al. 2009).

**Figure 1. Building Standard Climate Regions**




Source: Huang and Deringer (2007)

In order for the building energy standards to provide an effective impetus to the windows market, proper enforcement of the standards is crucial. New regulations resulting from the 11th Five-Year Plan, in which China set national development goals for 2006 through 2010, have substantially improved compliance at least in the major urban construction markets (Liu 2009). Performance evaluations of local government officials now take into consideration the fulfillment of energy conservation targets. Nevertheless, building inspection can strain the staff of local governments, both in locations with limited government resources and in locations with rapid construction growth. Therefore, further improvements are needed, some of which could be achieved by facilitating the inspection processes. In the case of windows, inspection has so far relied primarily on physical testing of product samples. This can be time-consuming and costly and it can be challenging to ensure that test conditions are consistent among the numerous test facilities involved. The planned windows energy labeling program promises to improve upon the current means of inspection by allowing inspectors to more easily verify that installed windows match the standard specifications. It would also ensure consistency among window energy ratings through standardized simulation and test procedures and quality control among the participating laboratories. The requirements for window energy performance thus depend on the building energy standards, but whether enforcement of these requirements is sufficiently effective to transform the windows market may depend on consistent and verifiable window energy ratings provided by the windows labeling program.

### Public Awareness and Demand

As Chinese urban living standards increase, so does the demand for better-performing windows. Growing expectations of thermal comfort may be a more important factor than energy savings considerations. Until the 1990s, cooling was nonexistent in China's residences, and heating was limited to the Cold and Severe Cold climate regions. Most residents in the cold climates still lack control over the schedule and amount of heat provided by their buildings. Since 1990, air conditioning has spread across China, and people in the Hot Summer Cold Winter climate region use air conditioners for heating as well. Many urban Chinese have gotten used to more amenable thermal conditions, and window performance makes a difference as to whether thermal comfort can be achieved. The energy-savings benefits of efficient windows are more difficult to assess, but they are also increasingly valued. In the South, occupants pay rising costs for electric heating and cooling. In cold climates, fixed or non-existent heating bills remain the norm, but recent reforms have led to a rise in occupant-controlled heating systems with consumption-based metering (Richerzhagen et al. 2008). Regardless of whether thermal comfort or financial concerns are the driver, increasing public awareness opens up market opportunities for energy-efficient windows. In the Shanghai market, for example, customers are increasingly aware of high-quality building product options and may demand low-e windows independent of whether these are required by building standards (Xu 2009).

With rising public awareness and encouraged by regional building research institutes, architects for high-end buildings are beginning to incorporate energy efficiency considerations into designs. However, in order to express demands for energy-efficient windows, consumers and design professionals need product information. To many Chinese, regular dual-pane windows are an energy-efficient option, which is true relative to the many existing single-pane windows. Some measure of how, for example, the performance of a low-e window differentiates them from conventional windows can help increase awareness of truly energy-efficient options. Window energy performance can be a complex topic, but the planned implementation of the labeling program will be an important first step to providing more information that is accessible to design professionals and the wider public.

## The Windows Energy Labeling Program

The conventional evaluation method for determining whether windows meet building energy standard requirements depends on product sample tests. Variations of window samples and test conditions are challenges for the consistency of such tests. The windows energy labeling program seeks to address these challenges through standardized procedures based on the combination of simulation and testing, independent oversight and manufacturer quality control. The program is overseen by the Research Institute of Standards and Norms (RISN), which has developed more than one thousand standards for construction industry products under supervision of the Ministry of Housing and Urban/Rural Development (MOHURD).

Figure 2 shows the RISN label template as of 2009. While the upper section of the label lists manufacturer general product information, the lower section shows the certified ratings of the window's *thermal transmittance*, *air leakage*, *shading coefficient*, and *visible transmittance*. Roughly similar, though not identical ratings are included in labels by several other countries.[6]

[6] Labels in Australia, Canada, Finland, Sweden, the United Kingdom and the United States, for example, include similar, though not identical, rating categories as the RISN label.

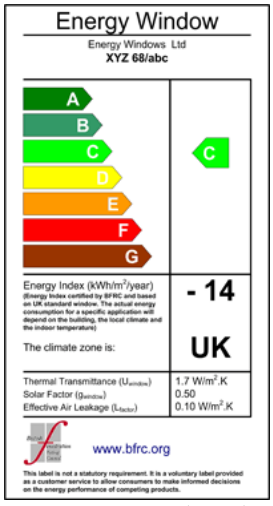
**Figure 2. The RISN Windows Label**


Source: RISN (2010)

**Figure 3. NFRC Window Label**


Source: NFRC (2006)

**Figure 4. BFRC Window Label**




Source: BFRC (2010)

In developing this program, RISN sought inspiration from existing programs in North America, Europe and Australia and consulted international experts with experience in these programs. General concepts under consideration were, among others, a label limited to technical ratings of distinct properties, such as the North American label by the National Fenestration Rating Council (NFRC), or a label including an assessment of how well the window performs, such as the British Fenestration Rating Council (BFRC) label. Generic versions of these labels are shown in Figures 3 and 4.

RISN decided to focus the label on technical ratings without an assessment of energy performance for several reasons: a) the label's main purpose is to allow comparison of the ratings with building design specifications and requirements in the building standards; b) the energy performance of different windows relative to each other depends on the climate where they are used and building conditions such as orientation, building type, and shading conditions; c) RISN does not currently have the authority to endorse any products based on their ratings. The only exception is a slot on the label that identifies "suitable regions" where the window would likely meet the building energy standard. Although more consumer-friendly information would be helpful in addition to technical ratings, this information may be provided through other media than the label.

The ratings for the RISN label are determined through a combination of computer simulations and physical tests by accredited laboratories that follow a protocol of standardized procedures. A special emphasis is put on training for laboratory staff to ensure that the ratings are consistent among laboratories and allow for fair comparison among products. Currently, the label is completely optional and has only recently been introduced for pilot implementation in select locations. The first labels were issued in 2009, eight years after RISN started researching the options for a windows rating system.

**Development of the labeling program**

The windows energy labeling program is administered by the Research Institute of Standards and Norms (RISN) under the Ministry of Housing and Urban/Rural Development (MOHURD, formerly the Ministry of Construction or MOC). Since its initial efforts in 2001, RISN has received consistent support from the Energy Foundation and advice from international consultants. From 2001 to 2006, RISN first addressed the technical issues of energy ratings by producing an industry standard for testing and calculating window energy properties, then the administrative issues by developing a management plan for a window energy rating system, and finally the legal issues by having both the technical standard and the management plan approved by the Ministry in December 2006. In 2007, RISN accredited eleven laboratories for rating window performance through simulating and testing under the new standards.

Pilot implementation of the labeling program began in 2009, when RISN coordinated local implementation plans with building research institutes in Beijing, Shanghai, Jiangsu Province and Guangdong Province. These local entities actively coordinate with the local building authorities and industry associations to gain their support and devise policy measures to accelerate the labeling experiment. By the end of 2009 the accredited laboratories had completed ratings and RISN had issued labels and certificates for the first two batches of products – one with 72 products from 17 companies, the other with 70 products from 13 companies (RISN 2010). With an estimated 10,000 window manufacturers in China, this is a small start, but this start will allow the involved parties to gain much-needed experience with the introduction of labeled products and pilot implementation of supporting policies.

Since any window can obtain the label as long as the rating procedures are followed, there is no guarantee that the windows bearing the label meet any particular energy performance levels. However, several opportunities for greater energy efficiency are within reach of the Chinese windows market, and the label may serve as a tool to help overcome important barriers.

## Potential Impact of Windows Energy Labeling

Successful implementation of the windows energy labeling program could help ensure that China's building energy standards and increasing public awareness effectively translate into the use of windows that push the supply side's energy efficiency potential.

### Potential impact on building energy standard compliance

The labeling program promises to improve building energy standard enforcement and compliance by offering consistent energy ratings information. Building inspectors can easily check on the label whether the window ratings meet the standard requirements and the specifications from the design stage. The label may allow for window inspections without the need for time-consuming validation testing of product samples. Inspectors could instead use a simplified sampling approach that takes advantage of the documentation trail from the performance simulations that are part of the labeling program. Instead of testing whole sample windows for their heat transfer properties, inspectors could examine random frame cross sections and glass samples that were made for use in the project. If these components match the specifications used for simulation, the windows could be considered validated. For this alternative to be acceptable, however, it would first need to be recognized by the standards, which currently require testing of whole-product samples of a project's windows.

To ensure consistency among the ratings from different simulation and test laboratories, the labeling program accredits only the more advanced among the existing testing entities to qualify as laboratories under the labeling program. The accredited laboratories have participated in extensive workshops offered by RISN to train laboratory staff in the application of the simulation software and in the other components of the ratings procedures. Moreover, RISN oversees inter-lab comparisons of test and simulation results so as to uncover possible inconsistencies and to ensure that ratings are independent of where the simulations and tests are performed.

There is not yet a formal role for the windows labeling program in the Chinese building energy standards and no official exemption of labeled windows from prevailing validation requirements. For labeled products to receive favorable treatment, the labeling program must prove that it delivers consistent and reliable ratings and that the actual labeled products match the designs on which simulations and ratings are based. Once the information on the label has earned sufficient trust, it can greatly simplify window inspection for compliance with energy standards and thus increase the chances for effective enforcement.

### Potential impact on public awareness

The labeling program can also help design professionals and the general public better understand the complex topic of window energy efficiency. This is no easy task. Even energy ratings that accurately capture window performance do not necessarily tell whether a given rating indicates a strong or a poor choice in a given climate. As an informational label with technical ratings, the RISN label was not designed to endorse energy-efficient windows and thus make it easy to find high-performance products. Therefore, the label is certainly more helpful for building inspectors than for consumers. Nevertheless, the labeling program can serve as a basis for related public information. As a start, the label includes a slot for "suitable regions" to show

climate regions where the window would likely meet the building energy standard. A database of the labeled windows could list products by suitable regions and help design professionals find available ratings data to improve their specifications. Moreover, as local government agencies, building research institutes and industry associations collaborate on the pilot implementation of the labeling program, they are preparing more thorough information on window energy performance through publications, websites and local outreach. This information will not be part of the label itself, but the implementation of the labeling system is a good occasion for the involved parties to team up in creating more awareness of the importance of window energy efficiency.

**Potential impact on window manufacturers**

If the labeling program succeeds to improve the enforcement of building energy standard requirements, window manufacturers will certainly have a compelling reason to invest in added production equipment for energy-efficient window designs. Regarding customer awareness, manufacturers of labeled windows may partner with regional building research institutes on providing outreach through conferences, web material, and publications. The Jiangsu Research Institute of Building Science, for example, is partnering with the provincial window manufacturers association to publicize the window labeling pilot program in Jiangsu Province (JSRIBS 2009).

On the technical side, participation in the labeling program can help manufacturers develop a better understanding of energy-efficient window design. Designing thermally efficient window frames requires know-how that many manufacturers are only slowly acquiring, oftentimes by copying other manufacturers (Xu 2009). Participation in the labeling program can help manufacturers to gain this know-how more efficiently. The computer simulation tools used to determine the ratings for the labeling program allow users to identify effective means of lowering thermal conductance through simple design changes. Manufacturers who learn to use these software tools will be better able to pursue thermally efficient design and witness the improvement in their products' ratings.

## Challenges for the Labeling Program

Implementation of the windows labeling program will require careful preparation by RISN, which is why in 2009, the waters were tested with pilot implementation in select locations. These pilot projects pointed to some challenges the program is facing. RISN has noted the following:

1. The first unauthorized labels have appeared;
2. Local construction authorities need to be given clearer responsibilities for managing the program's implementation;
3. So far, only a modest share of manufacturers is enthusiastic about participating in the program;
4. Policy support for promoting labeled products is still insufficient.

The first two issues can be addressed through legal and regulatory fixes that should not take too long to implement. The issue of manufacturer enthusiasm is clearly linked to the issue of supporting policies. If manufacturers see that policies are in place to promote labeled products,

industry buy-in will follow. The building research institutes and construction authorities of the four pilot project locations (Beijing, Shanghai, Jiangsu Province and Guangdong Province) have started to promote labeled windows through public education efforts. Jiangsu is planning to further promote the label by requiring that demonstration projects – high-performance projects that receive government incentives – must use labeled windows. Once labeled windows have become more widely available, the Ministry of Housing and Urban-Rural Development may consider requiring labeled windows under national programs for high-performance or green buildings. Such policies would certainly boost industry participation. In the near run, the priorities for implementation are to increase participation in the pilot locations and to address technical and procedural issues as they are discovered so as to establish a reliable program.

Experience will show what other implementation issues may prove to be problematic. One potential issue is laboratory oversight. The current eleven accredited test and simulation labs are regional research institutes that are well-connected with construction authorities within their regions. This close connection has benefits in that these labs can more easily encourage local authorities to promote the program, but a problem may be that local authorities are less likely to apply rigorous oversight to the work of these labs. Quality control of laboratory work is an important element of the labeling program, and RISN may have to make up for some of the oversight that may lack from local authorities. At the least, RISN will continue to require periodical training from laboratories as well as comparisons among test and simulation results to ensure inter-lab consistency.

## Conclusion: Lessons Learned from Pilot Implementation

When the Energy Foundation started supporting RISN's development of a windows labeling program in 2001, the prior experience with such programs came from developed countries: Australia, Canada, the United Kingdom, and particularly the United States. Applying this experience to China was an experiment that relied on RISN perseverance through several years of preparatory work and on advice from foreign experts. Now that pilot implementation of the program has started, it can be concluded that the transfer of technical know-how was successful. For example, Lawrence Berkeley National Laboratory software for thermal performance simulation is now used in its translated version by all participating laboratories. In 2009, Chinese experts developed their own simulation tools, to which the labeling program intends to transfer within the coming years.

If technical know-how could be transferred quite smoothly between the international role models and China's program, the differences in governance structures have proven to be a more substantial divide. China is implementing the labeling program within its existing administrative infrastructure, which means a greater role for national and local government agencies than for non-governmental entities. Consequently, the pilot implementation of the Chinese program provides lessons that RISN could not readily draw from experiences abroad. The Chinese market structure also differs substantially from that in North America, for example, in that China's construction market is focused on much larger projects while the windows are supplied by manufacturers of relatively small size if compared to their North American counterparts. These market differences affect important aspects of a labeling program, such as acceptable lead times for product evaluation, the quantity of manufactured window units typically covered by the ratings for one product line, the amount of oversight required to ensure adequate quality control among participants, and other issues.

Some countries considering the introduction of windows energy labeling may learn valuable lessons not only from the example of developed countries but also from the Chinese experience. India, for instance, is preparing implementation of windows labeling with technical assistance from the U.S. National Fenestration Rating Council and the idea has been floated in South Korea and Indonesia as well. These countries may benefit from the lessons learned not only by Western countries but also by China, where many aspects of the construction sector more closely resemble those of other Asian economies than the construction sectors in North America and Australia. The most appropriate way to administer a labeling program, however, invariably depends on each country's own governance infrastructure. China, for its part, is doing well by supporting pilot implementation of its windows energy labeling program in locations with strong technical and administrative capabilities before embarking upon the more difficult undertaking of establishing solid national coverage for this program.

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