A Road map to Building Material Testing and Rating in Developing Countries

Meredydd Evans, Mark Halverson, Linh Vu, Sha Yu and Huong Nguyen
Pacific Northwest National Laboratory

ABSTRACT

Most large developing countries have a building energy code or other building efficiency policies. However, testing and rating systems to assess the energy performance of building materials often lag behind these codes and policies. Building materials play a key role in setting the energy footprint of a building. Poorly performing or poorly labeled materials can result in higher energy use and lack of market incentives to produce high efficiency products. This paper provides an overview of the types of testing, rating and labeling systems in place the U.S., Europe, China and other large countries, highlighting elements that can make a system more robust or weaken it.

Then based on the example of Vietnam, the paper describes how a country can develop a road map for improving its system for testing, rating and labeling building materials for energy performance. Key elements include reviewing domestic capabilities and the institutional framework to test materials; certifying laboratories and building their capacity; prioritizing the test standards for development or adaptation based on clear criteria and stakeholder feedback; and designing labels and ratings. In addition, the road map can consider options to ensure that the new system is robust and meets domestic needs, for example, by providing incentives to products that get tested, having random testing of materials, and piggybacking the new system to test materials for energy performance on existing material testing systems for structural performance.

Introduction

Testing, rating and labeling systems for energy performance of building materials are fundamental building blocks of building energy efficiency policies[1]. The benefits of product testing, rating, and labeling can accrue at three levels – 1) Consumer – typically by helping consumers save cost, 2) Manufacturer – by providing a level playing field, and 3) Nationally, where benefits are typically associated with reduced energy usage or emissions (NFRC 2012a, NFRC 2012b, U.S. DOE 2015). Building an efficient building requires high-performance materials, and building material testing, rating and labeling allows people to easily and consistently understand how the building materials will perform. Material testing, rating and labeling also ensures that manufacturers have an incentive to produce high performance materials because they can easily convey superior performance to the market. In short, most building energy efficiency policies and programs benefit from clear information on materials. For example, with building energy codes, a label helps the construction company select the

[1] To avoid repetition and for ease of reading, henceforth when we mention testing, rating and labeling systems, we mean systems to test, rate and label building materials for their energy-related characteristics (unless otherwise specified). By building materials, we mean any built-in components that will make up the infrastructure of a building and that effect energy use, including windows and insulation, but also equipment such as lighting, HVAC and hot water heaters.

appropriate material, and it helps the code official easily verify that this material matches the code-compliant design (see Table 1). Rating and labeling materials make code compliance easier and more effective.

Differences in test protocols alone can result in 10-20% differences in stated performance levels, and presumably differences in the quality of testing can result in even greater discrepancies (RDHBE 2014). In other words, as developing countries move toward more and more efficient buildings, testing and rating can play a major role behind the scenes in facilitating higher performance in building materials and buildings themselves. We use Vietnam as a case study to illustrate the possible options and challenges in developing a material testing, rating and labeling system. Vietnam is a relatively large and fast growing developing country, with limited capacity today to test materials for energy efficiency properties, but a strong commitment to build this capacity because of a new building energy code. The Pacific Northwest National Laboratory is working with the Vietnamese Ministry of Construction and other stakeholders on a range of building energy efficiency issues, including building energy codes and systems to test materials.[2] This experience provides Vietnamese examples to illustrate the broader issues of developing a road map to building material testing, rating and labeling in developing countries.

Table 1. Building material ratings and labels in the code compliance process

Design phase	Construction phase
Designer specifies a product that meets the code. Building inspector reviews building design for compliance.	Construction company installs the specified material, using the material rating. Building inspector matches the label to the approved, code-compliant design.

Note: Green buildings would also involve a similar approach regarding design-stage specifications and construction-stage verification of material properties.

In addition to supporting building energy codes, strong materials testing and rating also make it easier to build green buildings, such as LEED-certified buildings. Currently in many developing countries such as Vietnam, green building consultants may need to send materials to another country for testing, which raises costs (including paying for tests, samples and shipping). Having a domestic system to test, rate and label materials would make it easier for everyone interested in green buildings to get high-performance products into buildings. The products of relevance here include any products specifically referenced in building energy efficiency policies, such as windows, insulation, lighting, heating, ventilation and air conditioning equipment and water heaters, to name a few.

Retrofit programs also rely on ratings and labels. For example, some countries provide low-cost or free retrofits for low-income households. Clearly labeled building materials help ensure that these programs meet their targeted energy saving goals. Governments and utilities sometimes also provide incentives such as rebates and tax credits for using certain high-efficiency products like high-performance windows. Again, rating and labeling can provide clarity on the material performance in a simple, yet robust way. Once testing, rating and labeling

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are available, manufacturers have an incentive to get their products rated in order to have a more competitive position on the market. Designers and construction companies can also benefit by easily being able to specify and use high-quality materials.

Thus, just as building materials are the building blocks of a building, material testing, rating and labeling systems are like building blocks of energy efficiency programs. The remainder of this article describes typical elements of a testing, rating and labeling system for energy efficiency; two examples of systems (in the United States and in Europe); and answers a serious of questions that may be helpful in designing such a system in a country just developing its capacity (drawing on the example of Vietnam).

Testing, Rating and Labeling System Elements

Typically, a testing, rating and labeling system for energy efficient building materials has several components:

1. Test standards. Test standards for specific building material properties can explain exactly how to test the materials for their performance in a standardized and consistent way. An example of the kind of testing issue that the standards should clarify is: in the case of U-value testing, should windows be tested across a wide range of temperatures, or a narrow range? In a country with extreme heat, it may not be appropriate to test windows in conditions that mimic only small indoor-outdoor temperature differentials. In most countries, governments or independent organizations adopt these test standards, and then policies may refer to these test standards (for example, the building energy code can state what test standard to use to determine properties such as solar heat gain coefficient).
2. Test laboratories. Test laboratories should have the necessary equipment, skills and certification.
3. Certification body. This body will certify that the labs have the appropriate equipment and skills to properly test the materials. Some countries have government certification of test labs; others have independent, not-for-profit organizations do this certification.
4. Rating procedures. The test results inform the rating that a material receives (the rating may simply be a statement of the performance, such as solar heat gain coefficient or SHGC). The same body that certifies the test labs may also review the test results and rate the materials. The rating typically involves more checks and balances than a single test.
5. Labeling. At the end of the process, it is helpful to have a clear label that the manufacturer can put on its product, explaining the material rating and any other relevant performance information.

While this approach represents a best practice, not all countries take this approach for all materials. Many countries are just developing testing and rating programs. China, for example, takes a very different approach. In China, construction companies send test samples to local test labs from each construction site to test for energy efficiency properties. This has created some conflicts of interest in that developers usually have close relationships with test labs; it is also quite costly. For safety tests of materials, China has now adopted a national testing system.

Examples of Testing, Rating and Labeling Systems: United States, Europe and Vietnam

United States. In the United States, independent, not-for-profit associations play a major role in organizing the testing, rating and labeling system for building materials. In the case of windows, the National Fenestration Rating Council (NFRC) manages the rating and labeling system. NFRC certifies test laboratories and rating agencies, develops testing protocols and rating procedures, and develops the window performance labels that manufacturers place on their products. The product certification and rating process for windows involves multiple steps, beginning when the manufacturer submits product drawings and specifications to a simulation laboratory so that it can test the product with computer simulation. The manufacturer also submits random product samples to a test laboratory for physical testing. Both sets of results are sent to an accredited Independent Certification and Inspection Agency (IA) for review. The IA assesses whether the testing and simulation were conducted properly. The IA also inspects the manufacturing facility for quality control. If the IA is satisfied with the results, it certifies the product and the manufacturer can place an NFRC label on its windows, specifying the performance characteristics of the window. The NFRC label includes a listing of the rated U-factor, SHGC, and visible light transmittance, as well as air leakage and condensation resistance ratings (where relevant). Manufacturers must resubmit their products for certification every 4 years. The U.S. Environmental Protection Agency issues an ENERGYSTAR label only for high performing windows with NFRC labels; there are tax benefits and other incentives for installing ENERGYSTAR windows. The U.S. model building energy codes also refer to NFRC ratings (ASHRAE 2013, ICC 2015).

Different building materials in the U.S. may go through different processes to be tested, certified and labeled. For example, labeling of building insulation materials is required in the energy code and is ultimately enforced by the U.S. Federal Trade Commission based on the U.S. Code of Federal Regulation (16 CFR 460 2005). The U.S. residential building energy codes reference standards that ASTM International developed for insulation. (ASTM International was formerly known as the American Society for Testing and Materials; it is an independent not-for-profit organization with a membership base). ASTM International uses a consensus process to develop standards. It also accredits laboratories for testing products against these standards. However, unlike with NFRC, it does not control the rating and labeling, which the U.S. Federal Trade Commission overseas in this case. The U.S. rule actually applies directly to home insulation, but since most insulation products are used for both residential and commercial applications, in essence all insulation must be labeled (16 CFR 460 2005).

The American National Standards Institute (ANSI) plays a major coordination role for standards in the U.S. and serves as the official U.S. representative to the International Standards Organization. ANSI is a member-based, not-for-profit organization that develops standards across a wide range of domains. It also plays a large role in accreditation of laboratories and other organizations that assess whether products conform to ANSI standards. ANSI recently worked with its members and constituents to develop a Standardization Roadmap for Energy Efficiency in the Built Environment.

European Union. In Europe, the European Commission now coordinates the building material testing and rating systems. Previously, some countries such as Germany had national systems and national test standards (e.g., the German Institute for Standardization, or Deutsches Institut

für Normung, DIN, which produced German standards). Under the 2011 European Union EU Construction Products Regulation, all affected building products must be certified with a Conformité Européenne (CE) marking label, which is valid across the EU. The test standards are also harmonized across Europe. The European Committee for Standardization (CEN), an association made up of national standardization organizations, sets the test standards for Europe, though typically industry initiates work on new standards (CEN 2015).

The CE marking certifies that the products are fit for their purpose, meaning they can perform within the for which they are certified; 2 of the 7 categories of purpose under the EU regulation include: energy economy and heat retention, and sustainable use of natural resources (BWF 2015, EUR-Lex 2011, Wellkang Tech Consulting 2015). For example, windows in Europe must have a CE label attesting that they have gone through an EU-approved test of energy performance. Windows in the EU must also have information on their performance in the Declaration of Performance that accompanies the CE Marking. The Declaration of Performance must be available for consumers upon request, but not all countries require that it accompany the product like a label, which can make it more difficult for code officials and buildings to comply with the code. In addition, most products must have installation instructions.

In the EU, test labs (called Notified Bodies) are designated at the country level, but the certification requirements and the list of approved Notified Bodies is overseen by the European Commission. Manufacturers also must have ISO certification of factory production processes and quality in most cases. Notified Bodies assess product performance, certify the "constancy of performance" and certify that the manufacturer has adequate factory production controls (European Commission 2015). While the majority of the system is identical across the EU, each member state determines specifically what technical characteristics the products must display. For example, some EU members already require energy labels rating residential windows from A to D (where A is high performance and D is not), while others do not.

Vietnam. Vietnam also has a well-developed system of standards for its products covering issues such as health and safety (for products ranging from chemicals to electronics), but, for the most part, the system does not yet cover testing building materials for energy-related properties (which is very common in developing countries). Still, it is helpful to understand the existing system as energy efficiency testing, rating and labeling will likely build upon the existing, more general system. The Directorate for Standards, Metrology, and Quality (STAMEQ) in the Ministry of Science and Technology oversees Vietnam's standards system. STAMEQ prepares national standards, supervises the implementation of rules and regulations on standards. It also develops accreditation policies, and provides product quality and system certification. The process of national standard development is designed to be transparent and to involve stakeholders through public review. National standards (called TCVNs) are developed based on scientific research and analysis of international equivalents. They are developed through technical committees that ministries such as the Ministry of Construction organize in cooperation with stakeholders. They are voluntary unless they are referenced in other laws or regulations that make their application mandatory.

STAMEQ maintains several certification bodies, including the Vietnam Certification Center, QUACERT. The Bureau of Accreditation (BoA) under STAMEQ maintains several accreditation schemes, including the Vietnam Laboratory Accreditation Scheme (VILAS). VILAS is a voluntary scheme that any testing laboratory can apply to (USCS 2015). The

Ministry of Industry and Trade also manages a labeling program that covers appliances and may soon expand to other building materials like windows.

Designing a Testing, Rating and Labeling System

Testing, rating and labeling systems can be developed in different ways, relying on either government agencies, private institutions or some combination. This next section focuses on how the system may function, including institutional design, testing of products, certification of laboratories and development of test procedures. The text is written around a series of questions that policy makers and other stakeholders could consider as they develop their systems.

Institutional Design

Institutional design addresses fundamental questions about any testing, rating and labeling – primarily "who will oversee the system" and "who will pay for the system".

Who will oversee the system? Having a clear line of responsibility for the overall system and for each product can make the system more robust. It is also critical to holding responsible parties accountable and ensuring coordination among relevant organizations. In Vietnam, STAMEQ serves in this role, but the Ministry of Construction and Ministry of Industry and Trade may be able to play a coordinating role among different institutions to make sure that the system covers the most important products from the perspective of energy efficiency. In the U.S., non-profit organizations such as the American National Standards Institute (ANSI) and the National Fenestration Rating Council (NFRC) lead the development of testing, rating and labeling systems. The federal government in the U.S. may have some role in certifying and labeling materials, depending on the product (see, for example, the description of insulation testing and labeling above). In Europe, the non-governmental European Committee for Standardization oversees the development of test standards, but the European Commission oversees implementation of the overall system for regulated products.

Many developing countries are in a situation like Vietnam's because they are expanding their system to cover energy efficiency properties of building materials. Thus to develop a robust testing, rating and labeling system, it may be helpful to consider key features of oversight organizations that have been important in U.S. and Europe (Table 2). In particular, four key features of oversight organizations include authority, objectivity, ability to take stakeholder views into account, and technical capacity to do the work required.

Table 2. Key features of oversight organizations

Feature	Significance
Authority	Typically comes in the form of the organization being designated by a government or in a major building standard for a particular activity. Absence of government designation may lead to competing testing, rating and labeling systems and potential confusion.
Objectivity	Addresses manufacturers' concern that their products are being tested and rated fairly
Consideration of stakeholder views	Enhances credibility of the organization, and helps in making the system practical and reflective of market conditions.
Technical capacity	Is critical to quality oversight and credibility among stakeholders.

Three specific steps that the entities that oversee the system must address include certifying labs, reviewing product rating applications, and developing and issuing labels.

1. Certifying labs. Certification of labs is at the heart of any testing and rating system. If labs are not capable of performing testing and rating of products in a consistent manner, the whole system falls apart. For example, a lab that only tests structural strength of materials may not be an appropriate lab to test for window SHGC. A lab run by a glazing manufacturer may not be an appropriate lab to select for testing all window products, including those of competitors.
2. Reviewing product applications and rating products. The certification agency should have clear rules on rating products and also the documentation and steps involved in applying for a rating and label. The certification agency also needs staff to review applications and lab results and match this with the rating categories.
3. Developing and issuing labels. Labels are critical in conveying information in a simple, easy-to-understand way. They make implementing a building code or energy efficiency policy much easier. Labels concisely summarize the testing results and rating. In an ideal world, products would be identically labeled with the same set of ratings developed by the same set of tests run by labs which are equally qualified to run the tests. (See also the section called "What are the elements of effective labels?" at the end of this document.)

Who will pay for the system? Cost is a fundamental issue for any testing, rating and labeling system as no system operates for free. There are three potential sources of funding for these systems, each with their own pros and cons.

1. Manufacturers can pay for the system. Since one of the intents of a testing, rating and labeling system is to ensure that a manufacturer's products perform as they are supposed to perform, the manufacturers of those products can be asked to pay to prove that their products are good. The test results would apply to those products nationally. This is the most common approach and can result in a very robust system because it is easier to design in regulatory checks and balances in a national system. Also, the overall costs are more reasonable than a system where developers must pay for tests from every new construction site. (See item 3 below). It is also possible to give manufacturers the choice to have their products tested by phasing in testing requirements and/or providing incentives for testing. This can ease manufacturer concerns about the cost of the system.

2. The government can pay for the system. If a government is interested enough in the energy efficiency improvements that are likely to accrue from a testing, rating and labeling system, the government may choose to pay for the development of the system. This approach provides complete control to the government, but at a cost to taxpayers. Limited budgets may also cause delays in processing applications, which can restrict the market. Typically, governments only pay for certain costs related to start-up or major system improvements, but governments rarely, if ever, pay for testing and rating costs.
3. Building developers (or construction companies) can pay for the system. In China, where such a system is dominant, all construction sites must send sample materials in for testing. China chose such a system initially because of the disaggregation of its building materials market. The government was concerned that rigorous, national testing would be too expensive for small local suppliers. However, this system has drawbacks in terms of the cumulative cost of the system, the lack of robust capacity for testing outside of large cities, and the close relationship that developers and construction companies have with testing labs. These factors can lead to improperly characterized materials, which do not perform as expected. It can also make code implementation more complicated because the materials do not have a label, but rather a test report.

In reality, support for a testing, rating and labeling system can be a hybrid of the manufacturer and government-funded systems. The government could develop the system and pay for its development costs. The government would then require or encourage manufacturers to use the system, which would essentially pay for the system's operating costs. Box 1 provides examples of how governments can encourage manufacturers to have their products tested and rated, even when it is not appropriate or feasible to require such testing.

Box 1 Manufacturer incentive programs

Countries have various approaches to encourage manufacturers to have their products tested and rated. For example, under the U.S. residential energy codes, there are punitive default values for windows that do not have an NFRC rating. These default values essentially represent the worst windows of each type and are typically 30% worse than average un-labelled windows. Manufacturers can sell unrated windows, but it is usually advantageous for them on the market to pay to have their windows tested and rated. In Denmark, the Danish Energy Authority entered an agreement with Danish windows manufacturers and glass trade organizations, where trade organizations would implement an energy rating scheme for windows while the government would promote Danish windows (Avasoo 2007). Many countries offer incentives for production and installation of certified, high efficiency products. In the U.S., the 2005 Energy Policy Act included a tax credit to incentivize production of energy-efficient refrigerators. In India, the government provides subsidies to ceiling fan manufacturers whose products meet the Super-Efficient Appliance label specifications (de la Rue du Can et al. 2014).

Testing of Products

Testing is essential to assess the energy efficiency properties of building materials. This section describes approaches to developing test procedures as well as institutional issues associated with testing.

How should developing countries such as Vietnam most expeditiously develop test procedures? Because Vietnam, like many developing countries, needs many test procedures and standards, it would be helpful to prioritize the test procedures to develop first based on clear criteria such as the importance of the material or characteristic for building energy efficiency, the ease of developing the test standard, and the appropriateness of referencing foreign standards in the interim. In Vietnam, the Pacific Northwest National Laboratory is working with the government and institutes on prioritizing and developing new test standards for the most important products (Halverson et al 2015). In a hot climate, testing windows for solar heat gain coefficient is likely one of highest priority test procedures to develop or adopt, given SHGC's impact on total energy use in hot climates.

Developing all the relevant test standards will take time. Thus, countries need to consider what to do regarding products for which there is no national test standard. Many countries refer to foreign test standards as an interim measure. This means that local building energy codes, incentive schemes and other policy documents would reference foreign test standards as the ones products must meet in order to show compliance or obtain the incentive. Factors to consider in selecting foreign standards to reference include:

- Climate: Is the standard relevant for the local climate conditions?
- Rigor: How rigorous is the standard?
- Market: Are a large share of these materials imported from a given country or region?

Will testing be done at the national level (with a single integrated system)? The alternative to national level testing with a single integrated system is testing at a regional or local level, perhaps with variability in the system used because of differences in capabilities in the regions.

Should testing be mandatory, and if so, in which cases? Once a country has testing, rating and labeling requirements, should all products be tested and labeled, or will testing remain voluntary? In the U.S., testing and labels for building materials are voluntary in most cases, but there are incentives for using labels. In Europe, products must have the CE label when appropriate, but this does not always require testing or labeling with performance information. It can, in some cases, involve self-certification with some controls.

Should test labs randomly pull products from the market, or test manufacturer-submitted samples? Manufacturers are always focused on the cost of their product and some manufacturers may be tempted to cut corners to make a less expensive product. Those manufacturers liable to cut corners could consider submitting superior sample products for testing, while creating lower quality products for sale. One way to avoid this "gaming" is to require testing to be conducted on products from the market, such as wholesalers' or retailers' shelves. This approach requires the test labs to spend money to buy products, but it does provide assurance that the products being

sold are the same quality as those tested. Manufacturers will need to pay a slightly higher testing fee to cover the purchase of sample products.

Should there be additional manufacturing site inspections periodically to verify quality? Many testing and rating systems look at the quality of manufacturing in addition to the quality of individual products to help ensure consistent product quality. For example, in the U.S., part of the NFRC rating process involves site visits by inspection agencies to manufacturing facilities to ensure that products are being produced in accordance with standards.

Certification of Laboratories

Certifying laboratories helps ensure consistent and robust quality of the testing.

What steps should be involved in certifying laboratories? Typically, laboratory certification involves an application describing the laboratories' capabilities and equipment. The laboratory must demonstrate that it has competent staff with knowledge, experience and equipment for the test(s) for which it seeks certification. The rules for certification should be public and clearly documented. Laboratories may need to be recertified every few years to ensure that they have maintained their capabilities.

Should the system require comparative testing? Comparative testing, also known as round robin testing, can ensure that test results are consistent across all laboratories. Round robin testing is typically used on a periodic basis to assess system robustness. Globally it is considered a best practice for this reason, though not all countries require round robin testing. Round robin testing can also be required as part of the certification or recertification process. This is the case, for example, for fenestration testing laboratories in the U.S. (Wise 2001).

What steps would be most effective in building laboratory capacity? Most developing countries have limited capacity today to test materials for energy efficiency properties. Building capacity requires training and equipment. Training can involve specialized courses and/or visits to foreign testing laboratories with experience. Initially, Vietnam and other developing countries may have a relatively small number of test labs with capacity for testing the energy efficiency performance of building materials because it takes time to build this. Regarding equipment, in most countries, labs fund the purchase of their own equipment knowing that they will be able to make money by selling their testing services. Development banks have also funded testing equipment in a few countries in conjunction with energy efficiency loans. Some developing countries such as India have built and calibrated their own equipment, saving on cost. Thinking through the business model for the laboratories is important in building a robust system, and the business model may be slightly different in the early years to get things started.

Labeling

Labeling allows all the key stakeholders to quickly find information on the energy properties of materials, and as such, it can mainstream the use of high-performance materials.

What are the elements of effective labels? Experience with appliances shows that energy labels should be designed in consideration of four major parameters: comprehension, salience, information, and appeal. Building material labels will have a different audience and role than appliance labels, since in most cases, construction companies and contractors will buy them. To demonstrate compliance with a building energy code or other efficiency policy, it is important for the material label to have data on key energy properties, such as U-value. However, building material labels should still be as easy to understand as possible. International research on energy labels has identified the following elements of effective label designs (Egan and Waide 2005):

- Minimizing unnecessary technical terminology and employing appropriate visual images can make the label more consumer-friendly and graphically appealing.
- Good formatting can provide clear information on the products' characteristics and guide consumers on which elements are the most important. Highlighting key information with bold or colored fonts can make the label more understandable and appealing.
- Government endorsement in the form of a well-placed and non-distracting logo can often enhance a label's credibility.

It is also critical to secure consumer trust in the label's integrity through a rigorous and transparent certification and testing process. Information campaigns and marketing training for retailers can encourage consumers to look for the label and help them understand the savings potential from the use of energy-efficient products (Egan and Waide 2005).

Conclusions

Testing, rating and labeling systems for building materials are an essential element of most building energy efficiency policies. Vietnam is enhancing its standards for the built environment with a particular eye toward improving building energy code implementation in new buildings. Vietnam has an existing system of standardization that includes testing and rating of many products. However, the system does not, for the most part, cover the energy efficiency properties of building materials. This presents the Government of Vietnam with an opportunity to build a system from the bottom up, learning from international and Vietnamese best practices. Examples of these best practices include ensuring that the test standards are rigorous and match the needs of a hot, humid climate, as well as designing product testing so that results are accurate and consistent. Other countries that aim to improve energy efficiency of the built environment may also learn from these best practices. When high performance materials get the credit they deserve through clear testing, rating and labeling, the market for these products expands and it becomes easier to build energy efficient buildings.

References

16 CFR 460. Title 16 of US Code of Federal Regulations Part 460. 2005. *Labeling and Advertising of Home Insulation*. Accessed May 13, 16. www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title16/16cfr460_main_02.tpl.

ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers). 2013. *ANSI/ASHRAE/IES Standard 90.1-2013 -- Energy Standard for Buildings except Low-Rise Residential Buildings*. Atlanta, GA: ASHRAE.

Avasoo, D. 2007. "The European window energy labelling challenge." In *Proceedings of the European Council for an Energy Efficient Economy (ECEEE) 2007 Summer Study*: 4-9. Stockholm, Sweden: ECEEE.

BWF (British Woodworking Federation). 2015. **"**Preparing your joinery manufacturing business for CE Marking". Accessed December 11. www.bwf.org.uk/toolkit/ce-marking.

de la Rue du Can, S, G. Leventis, A. Phadke, and A. Gopal. 2014. **"**Design of incentive programs for accelerating penetration of energy-efficient appliances*." Energy Policy* 72: 56-66.

CEN - European Committee for Standardization. 2015. "Construction products." Accessed December 10. www.cen.eu/work/areas/construction/products/Pages/default.aspx.

Egan C, and P. Waide. 2005. "A multi-country comparative evaluation of labelling research." In *Proceedings of the European Council for an Energy Efficient Economy (ECEEE) 2005 Summer Study*. Stockholm, Sweden: ECEEE.

EUR-Lex – Access to European Union law. 2011. *Regulation (EU) No 305/2011 of the European Parliament and of the Council.* eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32011R0305.

European Commission. 2015. "Construction Products Regulation – Notified Bodies." Accessed December 10. ec.europa.eu/growth/sectors/construction/product-regulation/notified-bodies/index_en.htm.

Halverson, M., M. Evans, L. Vu, and S. Yu. 2015. *Vietnam's Energy Efficiency Building Blocks: Recommended Priorities for Technical Standards and Guidelines in the 2013 VBEEC to Support Vietnam's Building Energy Efficiency Code and Related Policies*. Richland, WA: Pacific Northwest National Laboratory.

ICC (International Code Council). 2015. *International Energy Conservation Code*. Country Club Hills, IL: ICC.

RDHBE (RDH Building Engineering Ltd). 2014. *International Window Standards. Final Report.* Vancouver, Canada: RDHBE.

NFRC (National Fenestration Rating Council). 2012a. *The NFRC Label: A Tool for Meeting and Exceeding Building Energy Codes*. Accessed May 13, 16. www.nfrc.org/docs/2012-NFRC-Building-Codes-Publication.pdf

———. 2012b. *How NFRC's Third-Party Certification Program Helps You Improve Sales*. Accessed May 13, 16. www.nfrccommunity.org/resource/resmgr/fact_sheets/why_certify_fs.pdf

USCS (U.S. Commercial Service). 2015. “Vietnam Country Commercial Guide – Trade Regulations, Customs and Standards: Vietnam – Trade Standards.” Accessed December 22. apps.export.gov/article?id=Vietnam-Trade-Standards.

U.S. DOE (Department of Energy). 2015. *Saving Energy and Money with Appliance and Equipment Standards in the United States*. Accessed May 13, 16. energy.gov/sites/prod/files/2015/02/f19/equipment_standards_factsheet_updated_Feb_11_2015.pdf

Wellkang Tech Consulting. 2015. “CE Marking.” Accessed December 10. www.ce-marking.org/how-obtain.html.

Wise, D., and B. Shah. 2001. “An Assessment of Interlaboratory Repeatability and Reproducibility in Fenestration Energy Ratings: 1999 and 2000 NFRC Interlaboratory Round Robin Tests.” In *Proceedings of the Thermal Performance of the Exterior Envelopes of Whole Buildings VIII Conference*. Clearwater Beach, FL: ASHRAE.