Delivering Energy Savings in Buildings

International Collaboration on Building Energy Code Implementation

IPEEC Building Energy Efficiency Taskgroup

ipeec
International Partnership for Energy Efficiency Cooperation

Contents

Abbreviation List

BAU Business As Usual
BEET Building Energy Efficiency Taskgroup
EJ Exajoules (10^{18} Joules)
GBPN Global Buildings Performance Network
GHG Greenhouse Gas
G20 Group of Twenty
IEA International Energy Agency
IPEEC International Partnership for Energy Efficiency Cooperation
MEF Major Economies Forum on Energy and Climate
NZEB Nearly-Zero Energy Building (Net-Zero Energy Building in some countries)
PNNL Pacific Northwest National Laboratory
UNDP United Nations Development Programme
VLEB Very Low-Energy Buildings

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Executive Summary

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The potential benefits of building energy codes are numerous. With effective codes, buildings can deliver energy services to households and businesses using a fraction of the energy used today. In fact, comfort and productivity could even be improved. Jobs and markets could be created in new industries for energy saving technologies. Pollution in homes and cities and heat-trapping greenhouse gas (GHG) emissions could be curbed, protecting human health, well-being, and prosperity. The promise is great. But realising that promise requires the successful implementation of codes. Countries are learning how to implement codes more effectively. Through enhanced international collaboration, they can accelerate this progress to achieve superior energy performance in buildings at home and globally.

Building energy use accounts for over one-third of global energy consumption and is growing at a rapid pace. From 2000 to 2012, final building energy use for the world grew from 102 exajoules (EJ) to 120 EJ (an 18% increase), with the member economies of the Major Economies Forum on Energy and Climate (MEF)[1] and G20[2] accounting for approximately three-fourths of the global total during this period. If unrestrained, global final building energy use could increase by 50% from 2012 to 2050.

However, the effective implementation of energy efficiency policies would spur the diffusion of best-available technologies and practices, with the potential to save in the range of 53 EJ per year globally by 2050—an amount equivalent to the combined building energy use of China, France, Germany, Russia, the United Kingdom, and the United States in 2012. The countries represented in the MEF could collectively achieve a great majority of these savings—37 EJ per year by 2050—a 30% reduction relative to business as usual and consistent with achieving the 2°C energy scenario of the International Energy Agency. The remaining G20 economies could add savings of 2 EJ per year by 2050.

The reduction of building energy use would deliver a number of benefits: lower electricity and fuel costs for households and businesses; greater reliability in meeting energy demand without costly infrastructure and disruptions; and reductions in emissions of heat-trapping GHGs and other pollutants that pose a threat to human health.

Building energy codes (standards, regulations) are major tools to realise the energy savings potential in the building sector. Ambitious building energy codes are

1. MEF membership includes Australia, Brazil, Canada, China, the European Union, France, Germany, India, Indonesia, Italy, Japan, Korea, Mexico, Russia, South Africa, the United Kingdom, and the United States (www.majoreconomiesforum.org).

2. The G20 members beyond the MEF are Argentina, Saudi Arabia, and Turkey. G20 guest countries include New Zealand, Singapore, and Spain.

consistently regarded as amongst the most cost-effective policy measures for delivering large-scale and long-term energy savings and GHG emissions reductions. They accelerate the diffusion of energy-saving products and practices, improving energy performance and lowering operating costs in buildings for decades. Codes can also reduce peak electricity demand, create local employment, and improve the health and well-being of occupants.

This report provides an overview of the IPEEC Building Energy Efficiency Task-group (BEET) project on opportunities for international collaboration on building energy codes amongst the major economies represented in the MEF and G20 (known as the BEET 3 project). Specifically, the BEET 3 project focused on code implementation and compliance activities critical to realising the energy, financial, and climate benefits of building energy codes. Here, implementation refers to the establishment of administrative structures to put the code into practice and compliance refers to the adherence of a building to the provisions of the code. Effective implementation and compliance include a number of interconnected elements, including training and awareness programmes; building plan review and site inspections; supportive infrastructure such as software tools to check designs; meaningful penalties for non-compliance; and building material testing, rating, and labelling systems that allow for quick assessment of whether materials meet code-approved design requirements.

What Are Building Energy Codes?

For simplicity, this report uses the term building energy codes (or, simply, "codes") to describe mandatory requirements on building design and construction for improved energy performance. Some countries use different terminology, such as standards or regulations, to describe this same policy measure.

Countries have taken different approaches to code design, implementation, compliance (required, voluntary, or a combination of the two), and pathways to compliance. Codes differ in their stringency and scope. Some countries have post-construction requirements; some do not. Jurisdictions can update codes on a fixed schedule or from time to time.

Still, there are a number of commonalities across countries. For example, in many cases, the national government plays a lead role in developing the code, but local governments decide whether to adopt and implement the code. Further, the challenges that countries face in code implementation (e.g., in the lack of compliance with codes) and the range of policy options for addressing these challenges have many commonalities.

The value of international collaboration lies in exchanging information, approaches, and experiences in code implementation to address common challenges in various contexts. Even though building code requirements and related practices differ from country to country (and often within countries), discussion of issues, provision of technical information, and other forms of international knowledge exchange can increase the effectiveness of in-country implementation activities.

The BEET 3 project included data collection on current code status in MEF and G20 countries; development of candidate areas for collaboration by non-governmental building energy experts; and phone discussions and webinars with experts from participating governments to identify and refine priorities. Based on these project inputs, this report identifies key areas for international collaboration in building energy code implementation and compliance.

Collaboration Areas for Building Energy Code Implementation

Governmental participants in the BEET 3 project indicated strong interest in several areas for international collaboration outlined below (ordered by level of interest), as well as specific priority topics within each area.

Code Compliance Checking Systems. Checking systems for code compliance are sets of processes to determine whether buildings effectively meet applicable energy code requirements. Compliance checking systems ensure the credibility of the codes programme and the accountability of designers, builders, and users in meeting the requirements. Compliance processes can help local and national governments track the progress of code implementation. Compliance checks can also play a key role in building trust amongst stakeholders and instilling confidence in the market to deploy and invest in energy-efficient building technologies.

To improve systems for code compliance checking, countries could collaborate to:

- Identify effective practices in conducting physical checks of buildings, including who conducts the checks, how, and when.
- Implement simplified code compliance systems, especially when there is little local capacity and a need to phase in systems that are low-cost and minimally time-consuming.
- Share experiences of cities, regions, and countries on the efficacy of code compliance checking systems.
- Develop and share evidence-based studies on the effectiveness of different approaches to enforcement.

Measuring Performance against Code-Required Design. The measurement of actual energy performance is important in order to understand the real impact of building energy codes. Collecting data on the actual consumption of buildings can help support the design and implementation of more targeted building policies, while also closing the policy loop by providing data to support the evaluation of existing measures and the development of meaningful updates.

To improve the measurement of performance, countries could collaborate to:

- Develop and track metrics on the gap between actual building energy performance and code design.
- Exchange information on energy performance measurement methodologies (e.g., for whole-building performance and different end uses) and share lessons learned about the policy implications from measurement studies.
- Gather data on building characteristics and energy use and establish performance benchmarks for building types, including through collaborative studies.

Compliance Software and Tools. Many countries have software and tools to support building energy code compliance. Software and tools are used to assist developers, builders, and designers in demonstrating code compliance and to create compliance reports for code officials. They, therefore, help mainstream code implementation by simplifying and clarifying compliance with building energy codes.

To improve the utility of compliance software and tools, countries could collaborate to:

- Integrate code compliance checking software with design software so that compliance can be evaluated early in the design stage.
- Improve the robustness and user-friendliness of software for both the performance and prescriptive paths to compliance.
- Where software does not exist, develop and share simplified spreadsheet tools.
- Improve training in the use of performance-based simulation software for more effective whole-building compliance checking.

Incentives: Penalties and Positive Motivators. Although codes are usually mandatory, during implementation there may be low levels of compliance. Therefore, successful building energy code implementation must include disincentives for noncompliance (e.g., fines or denial of occupancy permits). Some countries also choose to have positive incentives for performance (e.g., "green" loans and subsidies) in order to ensure robust code implementation and catalyse market transformation toward high-performing buildings. Incentives can enhance motivation for compliance, particularly where gaps exist. They can also test the market readiness of potential future code measures.

To improve incentives, countries could collaborate to:

- Develop evidence-based information on the effectiveness of different incentive schemes.
- Share information on incentive programmes for beyond-code performance and very low-energy building (VLEB) policies.
- Exchange information on innovative ways to incentivise private sector initiatives in code compliance.

Forms of Collaboration

Government representatives expressed strong interest in the following forms of collaboration (amongst other forms). With the support of governments, the IPEEC BEET and its partners could facilitate country actions in the areas outlined above through recommended forms of collaboration, including the following:

- **Web Portal:** Expand the BEET web portal on building energy code implementation with tools, resources, and educational and training materials.

- **Webinars:** Establish a codes-focused webinar series on key collaboration areas for code implementation and compliance to share knowledge, experience, and lessons learned.
- **Network of Experts:** Further build a network of experts in code implementation to share best practices and provide expert guidance to one another and to other policy officials.
- **Best Practice Guide:** Develop a best practice guide on options for code development, implementation, compliance, and enforcement programmes.
- **Collaborative Studies:** Conduct collaborative studies on code topics of mutual interest, such as measuring building performance compared to the code and evidence-based studies on different compliance approaches.

Conclusion

National and subnational governments are ultimately responsible for adopting and implementing building energy codes. Where appropriate, international collaboration can play a critical role in helping governments to advance their own priorities, through the sharing of policy best practices, improving analytical capabilities, and providing other resources that accelerate and maximise the benefits of building energy codes.

2 Introduction

Building energy use accounts for over one-third of all global energy consumption and is growing at a rapid pace (Clarke et al., 2008, IEA, 2013; Urge-Vorsatz et al., 2012). From 2000 to 2012, total final building energy use for the world grew from 102 exajoules (EJ) to 120 EJ, an 18% increase (IEA-IPEEC, 2015; IEA, 2015). The countries represented in the Major Economies Forum on Energy and Climate (MEF) and G20 accounted for approximately three-fourths of the global total during this period. If unrestrained, global building energy use could increase by 50% from 2012 to 2050.

However, the effective implementation of energy efficiency policies would spur the diffusion of best-available technologies and practices, with the potential to save in the range of 53 EJ per year globally by 2050—an amount equivalent to the combined building energy use of China, France, Germany, Russia, the United Kingdom, and the United States in 2012 (IEA-IPEEC, 2015; IEA, 2015). The countries represented in the MEF could collectively achieve a great majority of these savings—37 EJ per year by 2050—a 30% reduction relative to business-as-usual and consistent with achieving the 2°C energy scenario of the International Energy Agency. The remaining G20 economies could add savings of 2 EJ per year by 2050.

The reduction of building energy use would deliver a number of benefits: lower electricity and fuel costs for households and businesses; greater reliability in meeting energy demand without costly infrastructure and disruptions; and reductions in emissions of heat-trapping greenhouse gases (GHGs) and other pollutants that pose a threat to human health.

Building energy codes (also sometimes called standards or regulations)[1] are major policy instruments in efforts to realise the energy savings potential in the building sector. Ambitious building energy codes are consistently regarded as amongst the most cost-effective policy measures for delivering large-scale and long-term energy savings and GHG emission reductions (IPEEC, 2014; Lucon et al., 2014). Codes may spur the acquisition and use of energy-saving products and practices, thus improving energy performance in buildings. Such improvements can persist for many decades, saving energy and lowering costs. Codes can also reduce peak electricity demand, create local employment, and improve the health and well-being of occupants (IPEEC, 2014).

Because of the utility and many benefits of building energy codes, energy efficiency experts participating in the Building Energy Efficiency Taskgroup (BEET)

1. For simplicity, this report uses the term building energy codes, building codes, and codes in an equivalent fashion. Some countries use other terminology, such as standards or regulations, to describe this same concept of mandatory requirements regarding a building's design and construction in order to improve energy efficiency.

of the International Partnership for Energy Efficiency Cooperation (IPEEC) identified building energy codes and their implementation as key areas for international collaboration in the report *Building Energy Efficiency: Opportunities for International Collaboration* (BEET 2 report)—a report produced for the MEF in May 2014.

In September 2014, the MEF asked IPEEC to work with MEF governments to serve as an international forum for collaboration to improve the energy performance of buildings in MEF countries, such as through efforts on codes, and building ratings and disclosure. The G20 also selected the IPEEC BEET as the implementation body for the G20 Energy Efficiency Action Plan (G20, 2014), which was finalised at the G20 summit in Brisbane, Australia in November 2014. This BEET report (known as the BEET 3 report) serves as an update to the MEF and G20 on IPEEC's collaborative work on building energy code implementation (known as the BEET 3 project).

The focus of this report is on implementation and compliance in building energy codes—critical elements for achieving long-term, large-scale building energy savings globally. Here, implementation refers to the establishment of administrative structures to put the code into practice and compliance refers to the adherence of a building to the provisions of the code. It is widely recognised amongst MEF and G20 government representatives that more robust building energy code implementation and compliance are critical to increasing energy savings. This was one of the major findings of the BEET 2 project, and project participants reinforced this conclusion in BEET 3.

A number of studies support these findings. For example, an analysis of the potential impact of building energy codes in China found that average building efficiency and total building energy use in the next century is closely linked to the extent of implementation. Stringent codes alone are not effective without robust implementation (Yu et al., 2014a). In the U.S., several evaluations of building energy code programmes have found that the extent of implementation support and compliance is critical to achieving substantial energy savings (e.g., Livingston et al., 2014). European evaluations indicate similar trends (e.g., McCormick & Neij, 2009; Togeby et al., 2009; Pan & Garmston, 2012; Evans & Yu, 2013). Thus, to realise all of the many energy, economic, health, and climate benefits of building energy codes, effective implementation is key, including appropriate compliance measures and programme evaluation. International sharing of best practices and collaborative capacity building can support effective implementation.

Section 3 of this report provides summary information about building codes, including common principles in implementation, as well as differences in the codes themselves and in implementation approaches amongst countries. Sections 4 and 5 present key areas for international collaboration in code implementation and key forms of collaboration identified by project participants, respectively. Section 6 describes the development of a web portal intended to play several roles in future collaborative efforts. Section 7 sets forth the report's conclusions, followed by a glossary, appendices, and references.

3 Building Energy Codes: A Summary

Building energy codes are an important policy instrument to improve energy efficiency in new and existing buildings. In China, for example, residential building energy codes require new buildings to be 65% more efficient than they were in the early 1980s.[1] The model national codes in the United States require new buildings to be significantly more efficient than buildings constructed even ten years ago; consumers in the U.S. save $5 billion a year as a result of the codes and the efficiency they have locked in to new buildings. Many other countries around the world are increasing the rigor of their building energy codes or adopting these codes for the first time (BEE, 2007; Evans et al.; 2009a; THUBERC, 2012; Livingston et al. 2014; Yu et al., 2014a).

At the same time, countries recognise that achieving energy savings requires not just adopting a code, but effectively implementing and enforcing it. Key implementation elements include training and awareness programmes; plan review and site inspections; meaningful penalties for non-compliance; supportive infrastructure such as software tools to check designs; and building material testing, rating and labelling systems that allow for quick assessment of whether materials match the approved design (IEA, 2008a,b; Harper et al., 2012; TERI, 2012; Stellberg, 2013; Yu et al., 2014b).

Code Designs for Compliance

Several different types of building energy codes exist, and often countries will allow multiple pathways for compliance. In simplest terms, one can break codes into five categories, as described in the Table 1.

Many countries actually have several compliance pathways that co-exist in their codes. The reason is that different designers and developers have different needs. Some designers and developers prefer a simple, low-cost approach to compliance and choose the prescriptive or trade-off options. Others would like to have flexibility in the design, and are willing to hire experts to do building energy simulation. Countries with a point system will typically also have certain prescriptive or mandatory requirements.

There is relatively little experience with outcomes-based codes to date, but much interest because of concerns that building energy codes do not cover plug

1. This includes envelope; heating, ventilation, and air conditioning; hot water; and mechanical. It does not include lighting, which is covered in a separate code.

Table 1. Typical Code Compliance Approaches

Code Compliance Approach	How it Works
Prescriptive	Prescriptive requirements provide specific rules on individual building components, for example how much heat windows transmit, typically expressed in tables. They are simple to understand and use, but do not allow flexibility. They may also limit how stringent the requirements can be, if the code does not also allow flexibility through other compliance approaches.
Simple Trade-Off	This approach specifies rules on simple trade-offs allowed between the otherwise prescriptive envelope components (e.g., less insulation but more efficient windows). It is also a fairly simple approach, and typically code compliance software helps ease calculations. It provides some flexibility. Simulation can lead to optimal designs, though typically in a code compliance context, designers seek to meet requirements, not optimise energy use. The flexibility provided by simulation may lead to lower costs for compliant materials.
Simulated Performance	In this approach, a proposed design is run in building energy simulation software to simulate energy use, which is compared either to a reference building or to a specified target (the latter typically in energy or carbon units). It usually requires expert knowledge and well-defined rules to do the simulation properly (Vizier, 2012; GBPN, 2014).
Point System	Points are assigned depending on the components used. More efficient windows or lighting would have higher points, and, to be compliant, a building would need a minimum number of total points. This is similar to many green building rating systems, and often countries with point systems will have incentives for specific levels of above-code compliance. These codes are most common in Asia (e.g., Japan and Korea) (Evans et al. 2009a,b,c; TMG, 2010).
Outcome-Based Code	This is a new concept and there are very few examples in place yet (New Buildings Institute, no date; Washington State, 2013). The idea is to regulate the actual energy use rather than the design, with penalties for excessive energy use in the first year (or on an ongoing basis). Implementation of such a code would be quite different from implementation of the other systems described above (Evans et al., 2014). Disclosure of actual energy use, which countries are beginning to require, would be a necessary step.

Sources: Hitchen, 2008; Evans et al., 2009a,b,c; Liu et al., 2010; TMG, 2010; IEA-UNDP, 2013; Washington State, 2013; Evans et al., 2014; and New Buildings Institute, no date.

loads or occupant behavior. Tokyo has a carbon cap-and-trade system involving commercial buildings that effectively regulates actual building energy consumption. The U.S. State of Washington has also considered adding code provisions that would require developers to post bonds until they can demonstrate compliant building energy performance in the first year of operation, but the proposal has not moved forward of late (Nishida and Hua, 2011; TMG, 2010; Washington State, 2013).

The stringency of code provisions also varies across countries and jurisdictions, but globally there has been a trend toward increasing energy efficiency requirements in most countries. It can be difficult to compare countries directly on stringency because climate zones and construction practices differ significantly.

What Codes Cover. Countries also differ in the scope of their codes. For example, the size and type of buildings covered can vary, and the extent to which renovations must meet energy requirements of the code can also differ. Some countries only regulate government buildings (such as Brazil[2]) or large commercial buildings (for example, India), while others regulate all buildings that have heating or cooling. EU Member States must introduce minimum energy performance requirements for buildings, building elements, and technical building systems, and set these requirements based on a cost-optimal methodology.

Building energy codes typically cover a range of different building components and systems. All the codes in countries surveyed in the BEET 3 project include requirements for the building envelope. These typically cover allowable heat loss (U-value), solar heat gain through windows, and window-to-wall ratio. Increasingly, codes also cover air tightness, shading, and building orientation (particularly in hot climates, orientation can have a significant effect on solar heat gain).

Codes also typically cover lighting, although in some countries, such as China, this is in a separate code. Other types of equipment like heating, cooling, ventilation, and water heaters are also usually covered. Ducts, pipes, and electrical supply may also be included. Countries do not typically include plug loads such as refrigerators, window air conditioners, and televisions within the code, although a few jurisdictions (e.g., Vietnam) have experimented with limits on maximum connected power load, and Brazil's code covers plug loads in federal buildings. Some countries (e.g., the United States) also have requirements for metering and submetering capabilities (MOHURD, 2004; ASHRAE, 2013; MOC, 2013).

Post-completion, some countries require additional measures, such as commissioning (United Kingdom), blower door tests (France, United Kingdom), periodic energy audits (Japan, Australia), periodic inspections of heating and hot water equipment (Italy, Sweden), posting of building certificates (EU), and regular reporting of metered energy data (Australia, New Zealand, Japan, and Denmark) (Evans et al., 2009a; McCormick and Neij, 2009; Zero Carbon Hub, 2010; EP-EU Council, 2010, 2012; DEA, 2012; Moneta et al., 2012; SEA, 2012; Vizier, 2012; Arcipowska et al., 2014).

Code Revisions. Best practice is for countries to revise their building energy codes on a regular basis. Appendix B highlights the code revision schedules of several countries. Having a fixed revision schedule can be very helpful. Such a schedule tends to lead to more frequent updates, allows market players to plan for changes, and ensures that there are ways to adapt the code over time as technology and market conditions change. The pace of revisions in most countries without fixed revision schedules has increased recently, following the general trends for growing stringency of energy efficiency requirements. Periodic revisions can also allow countries to learn from implementation programmes or to address loopholes.

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2. Brazil has requirements for labelling in federal buildings, but no minimum performance standards for buildings.

Common Principles for Implementation

Government representatives in the BEET 3 project made it clear that implementation of building energy codes is a key priority for improving building energy performance, and it is challenging everywhere.

Compliance Checking: Process and Players. Ideally, implementation and enforcement will include several elements:

- Plan review involves a comparison of the design against the code requirements. Any building that fails plan review will likely need design modifications before construction can begin.
- On-site inspections improve the chances that a building will be built to the code. Ideally, there will be several inspections at different points in the construction process. Inspections will typically involve sampling key building components or systems to compare them against the code-compliant, approved design. Some jurisdictions (in particular, China) have specific standards or rules for the documentation required during these inspections, while others have checklists of items to review. Inspectors will also usually require that any as-built changes get approved. Inspectors will check materials and equipment to ensure that their labels or test certificates indicate performance at the required level. Many countries have no or only limited on-site inspections because of local resource issues (MOHURD, 2007).
- Some countries use end-of-pipe tests instead of, or to supplement, on-site inspections. The most common such tests are air-tightness tests (also called blower door tests). Theoretically, inspections could also include use of infrared cameras to check for heat loss. Not all energy efficiency properties can be easily checked with end-of-pipe tests (solar heat gain is one example).
- A few countries also require additional steps, such as building commissioning, to ensure that all systems work properly before the building is ready to occupy.

In most cases, local governments play a key role in enforcing the building energy code, but they also must enforce health and safety codes, which are typically seen as a first priority.[3] With adequate resources it is possible enforce both, but this requires a clear understanding of the importance of the building energy code within the local government. Different skill sets are definitely an issue, and training is important. Most countries have limited resources and time, and individual inspectors, unless they are private, usually cover not just energy.

An additional challenge is coordination between the numerous stakeholders involved. Often, the national government may play a role in developing the building energy code and/or supportive tools, and in some cases, multiple agencies are involved (see Appendix C for more information on the role of the national

3. Examples of health and safety codes include requirements for structural soundness, fire safety, and seismic resistance.

government). There can be a gap between policy goals at the national level and resources available at the local level. There are also many private stakeholders. In some countries, the challenges with coordinating amongst all the stakeholders are most evident in developing and adopting the code, while in others, the challenge comes at the implementation phase.

Jurisdictions use different institutional models to implement the code (see Appendix D for additional information on these models). Some jurisdictions simply ask building owners to self-certify that their buildings comply (and hence there are no inspections), but most countries are moving away from this model because it rarely achieves strong compliance. In other jurisdictions, local governments are fully responsible for all reviews and inspections. In still others, private third parties conduct the reviews and inspections.

The advantage of using third parties is that it does not overburden local government, but third parties may have conflicts of interest, particularly if developers pay them directly. Some countries only allow trained and certified third parties to conduct reviews and inspections. There are several models that help reduce the conflict of interest. Local governments can collect a fee from the developer for the permit in order to hire the third parties. Third parties can lose their licenses if they do not perform their jobs properly. There can be random checks of the third parties by local government or other third parties (say, from a different part of the country, as Denmark does). In the U.S. State of Wisconsin, architects are required to ensure that construction matches their design or they can lose their licenses. The local utility can also serve as the code enforcer. In most of these cases, the local governments have at a minimum an oversight and review role. For example, China uses third-party inspectors, but local government officials come on site for additional checks at certain stages in the construction of urban buildings (NEEP, 2009; Evans et al., 2010; Shui, 2012; IEA-UNDP, 2013; Yu et al., 2013).

Having meaningful penalties for non-compliance is also important. In many countries, a developer cannot start construction until the design is compliant, and the local government only issues an occupancy permit once the inspections show the building matches the approved design. Some countries use fines, either in addition to or instead of withholding occupancy permits. Some jurisdictions also have incentives to encourage initial compliance or above-code performance (Evans et al., 2010; Conover et al., 2011); some examples are given in the discussion of this potential area of collaboration below.

Training and Education. In order to support implementation, most countries with building energy codes have several types of training and assistance. First, they usually have training programmes for different stakeholder groups. Training for local officials is essential to ensure that they understand the importance of the code and how to enforce it. Architects need training in the code design requirements. Construction companies need to understand how to properly install the correct materials. Training in building energy simulation is important for any simulated performance-based codes. Also, countries may integrate training on energy efficient building principles and code requirements into university curricula for architects and engineers. Countries may also have training for third parties who participate in plan review and building inspections. Not all jurisdictions use third parties, but most that do require some level of licensing or certification of the third parties. Qualified third parties can then perform plan reviews, prepare building energy performance certificates, and/or inspect actual construction for compliance.

Compliance Software. Another important tool is compliance software. Compliance software helps mainstream compliance by making it very easy for users to check whether their designs comply. In many countries, the software primarily checks for trade-off calculations, and designers who would like to use simulation will hire experts who can use approved but more general simulation programmes, such as eQuest, a free building energy analysis software package. A few countries, including France and China, have built simulation into their compliance software. This can encourage users to try more flexible designs, but it is critical to make sure that all users know how to properly use the more complex software. China's code compliance software also has an added feature: it is integrated with the most commonly used Chinese design software. In the BEET 3 project, several other countries expressed an interest in developing software with this feature.

Building Material Testing, Rating, and Labelling. Building material testing, rating, and labelling also constitute an important component of any building energy code system. Energy-saving building materials are critical to high-performance buildings. Tests can determine the properties of materials and equipment (such as efficiency levels); test protocols vary and can cover a range of likely conditions to test against. Test labs also may have varying degrees of skill in their craft; strong certification systems for test labs (ideally with round robin testing) can help improve consistency and quality. Several countries then integrate test results into rating and labelling systems. Rating systems may require random sampling of materials for testing and visits to manufacturing sites to verify quality. Finally, putting the results on a clear label helps all the construction stakeholders understand the properties and whether the material matches the specifications of the approved building design. Labels can also help manufacturers with high-quality products to distinguish those products from others in the market (Australian Industry Group, 2013).

Because manufacturers may not want to pay to have their materials certified, countries have taken different approaches toward incentivising industry. In the U.S. windows market, rated and labelled products have a market advantage because any unrated products must accept a deflated efficiency rating provided by default tables in the code. In Denmark, the government created a collaborative working environment with industry where industry agreed to more rigorous testing and ratings in exchange for government efforts to promote efficient windows.

4 Key Areas for International Collaboration

The BEET 3 project benefitted from the input and participation of MEF and G20 member and guest governments through their IPEEC representatives. The Global Buildings Performance Network (GBPN) and Pacific Northwest National Laboratory (PNNL) sought input from participating governments on collaboration areas of interest, holding discussions with representatives of 16 governments (see Appendix A for details). Governmental representatives also attended online webinars on February 2 and 6, 2015. During the webinars, PNNL and GBPN experts presented preliminary inputs and findings, and government representatives provided feedback and offered additional suggestions on collaboration areas of interest. In addition, a small number of non-governmental energy efficiency experts participated in BEET 3, providing input for an early draft list of important collaboration areas.

Based on discussions amongst non-governmental experts, the BEET 3 project team identified five areas that could benefit from international collaboration: code compliance checking systems; measuring performance; compliance software and tools; incentives; and building materials testing, rating, and labelling. The description below lays out each of the five areas, including a brief description of the area, and its boundaries and issues; the key opportunities and challenges; and specific topics identified by government representatives as being of interest for possible international collaboration.

The areas are discussed in order of priority. Appendix A shows that country participants indicated the highest interest in code compliance checking systems; all countries rated this area as high or medium interest, with no country indicating low interest. Three areas—measuring performance, compliance software and tools, and incentives—ranked about equally, all reflecting high interest, but somewhat less than in code compliance checking systems. Finally, one area ranked as a lower priority—materials testing, rating, and labelling.

Code Compliance Checking Systems

The term "code compliance checking systems" refers to a set of processes to determine whether buildings effectively meet applicable energy code requirements. Compliance checking systems ensure accountability of designers, builders, and users in meeting the requirements, and credibility of the codes programme.

Compliance processes can help local and national governments track the progress of code implementation. Compliance checks can also play a key role in building trust amongst stakeholders and instilling confidence in the market to deploy and invest in energy-efficient building technologies (Yu et al., 2014b).

Code compliance checking systems usually have several components, as described above under "Common Principles for Implementation."[1] Some jurisdictions employ different trained specialists for checking different building components (such as heating systems and the building envelope). Both the design and construction checks may involve local government officials, certified private third parties, or some combination; jurisdictions have taken different approaches to balancing the cost effectiveness and robustness of their compliance checking systems.

Finally, some jurisdictions may also have a separate system for evaluating the rate of compliance to learn from and improve implementation programmes. This may follow a set, statistical protocol for checking compliance levels in sampled buildings, possibly based on the weighted importance of different building components. In a simpler form, compliance evaluation may be an ad hoc assessment of different elements of the jurisdiction's compliance process, or an accounting of the number of code-compliant permits pulled. Compliance evaluation is critical to designing effective policies because it allows policy makers to make improvements to programmes over time based on empirical data (ADENE, 2013; GPO, 2013; IEA-UNDP, 2013; Yu et al., 2014b).

Key Opportunities and Challenges for International Collaboration. Government representatives identified code compliance checking systems as the area of highest interest for international collaboration. There is a wide range of systems

1. IEA-UNDP, 2013 provides a visualisation of this process.

across MEF and G20 countries, from those with little to no construction inspection, to those with plan review only, to those using third parties (with varying levels of standardization), to those that rely on local government for both. In most cases, countries reported that they had a wide range of compliance levels across different jurisdictions, particularly comparing large cities with smaller jurisdictions. Many governmental representatives indicated that they were still in the process of improving compliance checking and thus would welcome the opportunity to share experiences and lessons learned. Some of the participating countries would advocate sharing training and communication strategies with the goal of having implementers understand the importance of energy efficiency.

Moreover, most BEET 3 project participants recognised that this was a critical issue in terms of actual outcomes. Opportunities include accomplishing compliance checking faster and more efficiently, for example by using simple end-of-pipe tests; standardizing systems of checking (using spreadsheets or checklists, for instance); using third parties; and implementing mechanisms that would encourage the private sector and would not take too much time from local government officials.

Key challenges include gaining political support to conduct effective compliance checks (i.e., justifying robust checking based on empirical data), cost, and time burdens on local staff. Since compliance checking is inherently conducted at the local level, many countries expressed the need to involve local jurisdictions, possibly through national-level organizations that could help collate needs of local government and translate international experience to the local level. These difficulties are often compounded in federal systems where there is no national code and states or municipalities are free to adopt their own codes (or to adopt none at all).

Focal Areas. Government representatives suggested several topics for international collaboration that would help improve code compliance checking systems. Within this area, education, training, and awareness activities are very important both for policymakers and compliance officials, especially in countries that are at the beginning phases of implementation.

To improve systems for code compliance checking, countries could collaborate to:

- Identify effective practices in conducting physical checks of buildings, including who conducts the checks, how, and when.
- Implement simplified code compliance systems, especially when there is little local capacity and a need to phase in systems that are low-cost and minimally time-consuming.
- Share experiences of cities, regions, and countries on the efficacy of code compliance checking systems.
- Develop and share evidence-based studies on the effectiveness of different approaches to enforcement.

Measuring Performance against Code Required Design

The measurement of actual energy performance is important in order to understand the true impact of building energy codes. Collecting data on the actual consumption of buildings can help support the design and implementation of more targeted building policies, while also closing the policy loop by providing data to support the evaluation of existing measures and develop meaningful updates (Kjærbye et al., 2011).

As building energy codes become more stringent, the behavior of the occupants and the way the building is operated become more critical in achieving performance targets such as very low-energy or conservation targets. As a result, measuring the actual performance of buildings becomes more and more relevant. Measurement can also provide solid evidence on the benefits of the code, which can motivate adoption of stronger codes and highlight challenges with implementation, which also can help improve the effectiveness of codes.

One common approach is to measure performance in sample buildings against code-required design to inform policymaking; a few countries have broad requirements to measure and report actual energy use in commercial buildings (in particular, Australia, New Zealand, and Japan).

In order to support wide-scale performance measurement, metering capabilities for property owners and occupiers must be improved. Unlocking utility data would make detailed information available on actual performance. Enforcement mechanisms must also be adapted to take into consideration the energy performance of a building throughout its lifetime.

Key Opportunities and Challenges for International Collaboration. Sharing information on measurement can be useful for two reasons. First, methodologically, there are challenges with benchmarking buildings' energy consumption in order to compare the expected results with the measured ones. (For example, electrical appliances, which make up a growing share of building energy demand, are not normally addressed in the building energy code, though are often regulated through separate equipment efficiency standards.[2]) Linking building rating systems with measurement may provide one option to facilitate this process. Second, comparing results in different jurisdictions can be very helpful to policymakers in updating the code implementation and enforcement process (Ries et al., 2009; Heller et al., 2011; ADENE, 2013).

At present, the measurement and assessment of the actual energy performance of buildings is not standard practice in the majority of MEF and G20 countries, although there are occasional, limited pilot studies. Moreover, for most countries, the measurement of actual performance is not linked to current code implementation policy. Many government representatives noted the challenge of measuring performance and communicating this information without creating confusion.

Although understanding that empirical data on results can build support for codes and can help improve code implementation, government representatives in general knew their results would be very different from "code-implied" performance, and they were not always sure how to handle this. Having common methodologies to measure performance might help address some of these communication issues. It could also help countries more quickly design studies to differentiate between performance related to plug load versus performance issues directly linked to implementation of the code requirements.

Focal Areas. Government representatives emphasised the value of data in this area and suggested several topics for which international collaboration could be valuable. Web-based conferences were endorsed as a form of collaboration.

To improve the measurement of performance, countries could collaborate to:

- Develop and track metrics on the gap between actual building energy performance and code design.
- Exchange information on energy performance measurement methodologies (e.g., for whole-building performance and different end uses) and share lessons learned about the policy implications from measurement studies.
- Gather data on building characteristics and energy use and establish performance benchmarks for building types, including through collaborative studies.

Compliance Software and Tools

Many countries have software and tools to support building energy code compliance. Software and tools are used to assist developers, builders, and designers in demonstrating code compliance and to create compliance reports for code

2. For example, appliances such as window air conditioners, refrigerators, computers, and televisions (not larger electrical equipment, such as central air conditioners and electric hot water heaters, which may be regulated in the building energy code).

officials. They, therefore, help mainstream code implementation by simplifying and clarifying compliance with building energy codes.

Software will vary based on the details of the code and building types. Many countries have multiple paths for code compliance, allowing developers to choose between the simplicity of a prescriptive approach and the flexibility of a simulated performance approach.

For the trade-off or prescriptive approach, the software would calculate whether the specific measures in the building design meet or exceed the code. Such software usually includes a large library of typical building materials and assemblies to choose from, with built-in information on the performance characteristics of these assemblies. The software is usually designed to be robust, consistent, and easy to use. Using a software tool may or may not be required to comply with the prescriptive compliance path. For compliance based on simulated performance compliance, software is essential. Some jurisdictions may specify the types of tools and expertise required for such simulation, but the tools may not be specific for code compliance. Building energy simulation is complex and requires expert knowledge, which is why some jurisdictions may not develop specialised simulation-based compliance tools, although they allow simulation-based compliance.

In addition to software, countries may also develop other tools to help with compliance, such as detailed code implementation guides, code compliance checking protocols and checklists, and targeted compliance information for different types of experts.

Key Opportunities and Challenges for International Collaboration. Most countries expressed interest in this area, although many BEET 3 government representatives were not experts in this area. Some countries have well-tested and widely used software; others have basic software or none. Countries with small markets in particular would like to learn from others on existing tools to facilitate adoption of the latest tools and, if possible, find ways to easily adapt international tools.

Many countries would like to improve their software in several ways:

- Having code compliance checking software integrated with design software so that compliance can be evaluated early in the design stage.
- Improving the robustness of results for both the performance and prescriptive paths.
- Making software more user-friendly. Participants also specified a need for spreadsheet tools with simplified calculations where software does not exist.
- Developing skills for using performance-based software, with the recognition that results could be poor for whole building simulation when experts without adequate skills use the simulation software. Unaddressed, these capacity issues limit the effectiveness of whole-building compliance checking.

Government representatives recognized key challenges, including the need to involve specialised experts in this area and the fact that software must reflect jurisdiction-specific code requirements, building materials, and climate.

Focal Areas. Depending upon the existing use (or lack of use) of software tools, government representatives made a wide variety of suggestions about what topics could benefit from international collaboration, from highly technical topics to approaches for getting started.

To improve the utility of compliance software and tools, countries could collaborate to:

- Integrate code compliance checking software with design software so that compliance can be evaluated early in the design stage.
- Improve the robustness and user-friendliness of software for both the performance and prescriptive paths to compliance.
- Where software does not exist, develop and share simplified spreadsheet tools.
- Improve training in the use of performance-based simulation software for more effective whole-building compliance checking.

Incentives: Penalties and Positive Motivators

Incentives include various inducements to improve energy efficiency, such as penalties for code non-compliance and motivational programmes to encourage energy efficiency investments as a prelude to code requirements or as beyond-code measures. Prior to a code coming into effect, incentives can prepare the way, for example, in the form of loans and subsidies to developers and building owners. Although codes are mandatory, during implementation there may be low levels of compliance, which can be improved by targeted incentives. Successful building energy code implementation must include penalties for noncompliance (e.g., fines or denial of occupancy permits) and positive incentives for performance (e.g., "green" loans and subsidies) in order to ensure robust code implementation and to catalyse market transformation to high-performing buildings. Incentives can enhance motivation for compliance, particularly where gaps exist. They can also test the market readiness of potential future code measures.

Mandatory building energy codes set minimum energy requirements for the energy performance of buildings. These requirements are essential for lowering or removing the market barriers to delivering energy efficient buildings. Ambitious performance requirements can also generate innovation within the supply chain.

Building energy codes also provide the legal context within which minimum energy requirements can be enforced and required. Penalties help ensure compliance with building energy codes: the goal is to make compliance robust by making it easy and routine. Incentives can help motivate actors to go beyond the code, or to make compliance more mainstream when a country or city first adopts a new code (e.g., Ministry of Economy, Sustainable Development and Energy, 2014).

Sometimes the most effective incentives for code compliance are not financial in nature. For example, developers may get to jump to the front of the permitting queue if the building exceeds code requirements by a specific amount, or they may be allowed to build taller or have a modified building footprint. Such incentives can be very cost effective for local governments in stimulating the market initially, before a code takes effect; incentives may also allow for faster adoption of more stringent codes (Liu et al., 2010).

Financial incentives can also motivate households and building owners to pursue investments they would not otherwise have made or adopt practices they might not have otherwise engaged in (IEA, 2012).

Key Opportunities and Challenges for International Collaboration. Government representatives expressed a desire for information on empirical results that demonstrate the effectiveness of different incentive schemes; raw or basic information on this topic would not be so valuable. They indicated a mix of interests. Some favored voluntary approaches, and incentives could be part of such an approach; others thought it would be difficult to get political support for the investment in incentives. Some wanted information on how better to blend incentives with beyond-code requirements for buildings, building components, and very low-energy buildings (VLEBs)[3]; understanding the common elements of VLEB definitions is addressed in the BEET 4 report on building energy performance metrics (IEA-IPEEC, 2015). Challenges of international collaboration include the different national cultures and governmental forms; this is an area in which one size emphatically does not fit all. Moreover, in some cases there is a lack of political support because of the cost.

Focal Areas. Countries that were interested in this area included those that rely heavily on a soft approach and public-private partnerships. They were particularly interested in learning about results from various incentive schemes.

To improve incentives, countries could collaborate to:

- Develop evidence-based information on the effectiveness of different incentive schemes.
- Share information on incentive programmes for beyond-code performance and very low-energy building (VLEB) policies.
- Exchange information on innovative ways to incentivise private sector initiatives in code compliance.

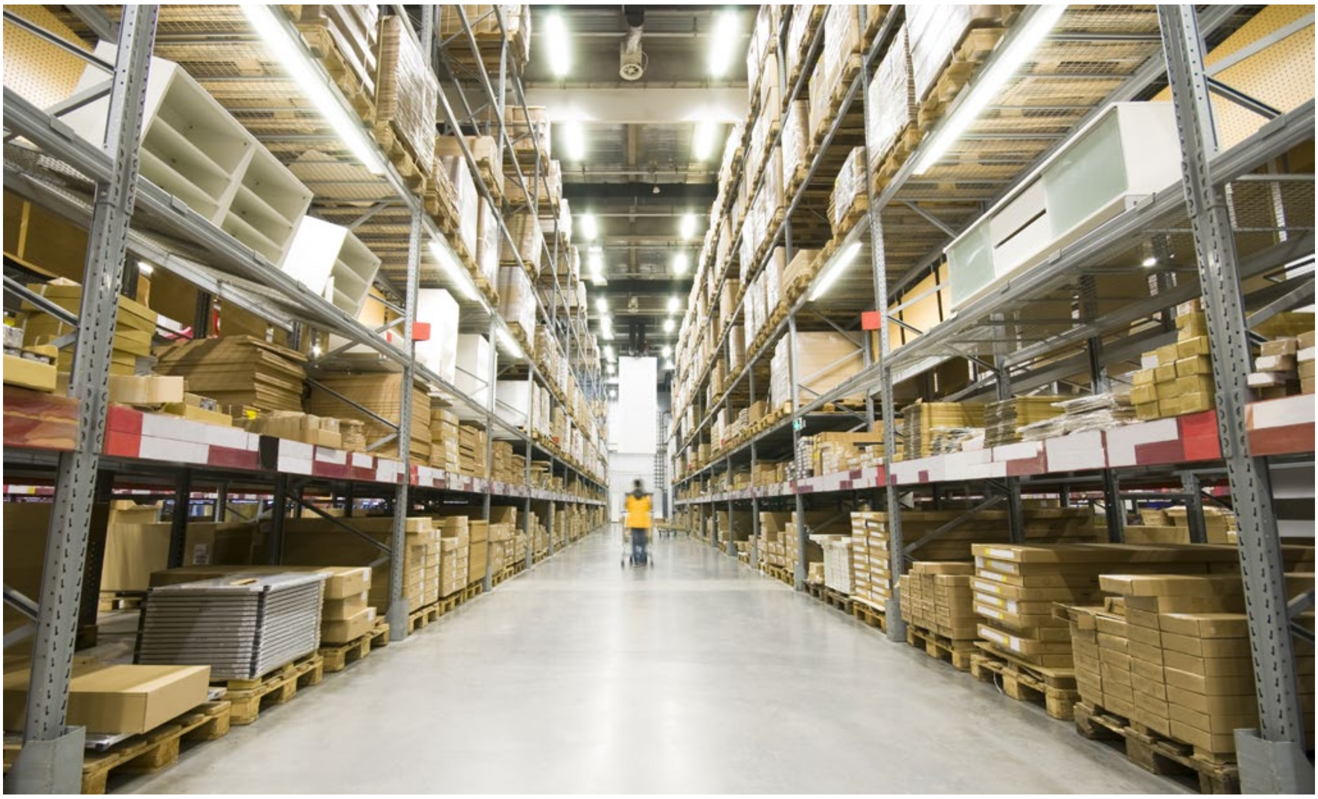
Materials Testing, Rating, and Labelling

A building energy code is most effective when it initiates a positive feedback loop of enforcement, supply of technologies and materials, development of compliance capacity, and expanded enforcement that is reinforced over time. Widely available, high-quality building materials and components are essential for facilitating compliance with the code. Therefore, market development strategies that increase the supply of products and assure their quality must be fostered in order to support implementation.

Testing, rating, and labelling programmes create a foundation for many policies related to building energy efficiency; see Table 8 in the *Technology Roadmap: Energy Efficient Building Envelopes* (IEA, 2013) for an assessment of countries' testing, rating, and labelling programme for building envelope materials. Robust materials testing and labelling can help ensure that insulation, windows, and other building materials will work as planned in creating high performance buildings. Developers, builders, building owners, and code officials all need to be able to easily understand the energy efficiency characteristics of building materials. This can be accomplished if there are clear ratings categories and if code requirements specify ratings for various materials. Providing clear information on the energy performance of building materials usually requires several elements:

- Agreed test protocols that consider a range of real-world conditions.

3. VLEB is the term used in current BEET work to encompass various terms (with different meanings) for low or no energy use buildings in different countries, including nearly zero-energy, net zero-energy, net zero-ready, and ultra-low-energy.



- Strong laboratory capabilities to conduct the testing, along with laboratory certification procedures and checking of comparative results for consistency between laboratories.
- A transparent, independent process for selecting materials to be tested and for conducting the material and equipment testing.
- Additional spot checks of manufacturers to verify production quality procedures and ensure that the material tests are representative of overall production quality.
- Clear labels to share key information on the energy characteristics of the materials (such as air tightness, thermal transmittance, or potential for solar heat gain).

In addition to helping ensure strong code compliance, materials testing, rating, and labelling can also support other building energy efficiency policies and help consumers when they purchase products for retrofits, supporting the market for high-performance building materials. Finally, many countries also have separate systems for certifying green building materials based on a range of sustainability characteristics. Green building material certification may take into consideration the environmental impacts of the products themselves, particularly their embodied energy and carbon footprint, which are additional to the energy and carbon from building operations.

Key Opportunities and Challenges for International Collaboration. Countries had a wide range of experience in this area: some have very extensive systems, while others have simple voluntary systems or rely on adherence to international standards. This is true even amongst European Union (EU) countries, where EU-wide testing and labelling standards exist.

Government representatives recognised the importance of materials standards for efficiency, and several countries mentioned their value where materials are imported or exported. Harmonising testing and rating systems, or having clear, comparative information on what building materials ratings mean is a clear advantage when dealing with imported products.

Challenges include concerns about the feasibility of cooperation—either because of difficulty in harmonising or because of lack of value for jurisdictions with strong systems. Also, there is a clear need to involve specialised experts (including those in academia or standards organisations who set standards and design testing systems).

Focal Areas. Some countries, particularly those in the Pacific region and those with less developed systems, were very interested in topics under this area. However, many countries had only a muted interest. Those interested in the area made several specific suggestions for focal areas.

To improve materials testing, rating, and labelling, countries could collaborate to:

- Share information on the relative meaning of ratings in different countries to understand imports and to highlight areas for improvement, perhaps in the context of round robin testing to compare these relative meanings.
- Exchange information on institutional arrangements for testing materials in different countries, which could help countries improve their systems.
- Share ways to bring innovative products to market more efficiently.

Other Potential Areas of Collaboration

In BEET 3 project discussions, government representatives suggested several other areas in which international collaboration holds potential benefits.

Training and Education. Sharing of approaches to training and communication of energy efficiency aspects of building codes would be beneficial to code compliance and implementation efforts. In the early stages of implementation, effective training is particularly critical to raise awareness and make compliance more mainstream. However, BEET 3 participants recognised that training would likely need to be adapted to different contexts and code requirements (Arcipowska et al., 2014).

Some commonalities in training programmes may include university curricula for efficient building designs, approaches to segmenting training by stakeholder group, and the use of social media and multiple media to expand the reach of training programmes. Thus, while training programmes may not be directly transferrable, the presentation of materials and means of sharing information in individual countries may provide inspiration and ideas for courses elsewhere.

Code Development and Stakeholder Involvement. Several countries expressed an interest in learning from each other in specific aspects of code development. In particular, countries would benefit from sharing methodologies for calculating cost-optimal code provisions (as in the EU) or cost-effective provisions (as in many countries). These methodologies typically include details on how to assess costs and benefits for different parts of the building stock and how to capture as much of the building stock as possible in a statistically representative, yet simplified way.

Likewise, some countries expressed interest in learning about the code development cycle elsewhere, and any feedback between lessons learned on implementation and code development. Equally important is the question of stakeholder involvement, which can have a critical influence on the ease of code adoption and implementation. Some countries have found ways to bring stakeholders together in collaborative ways to improve the process, while others find that stakeholder relations remain a challenge in this area.

Standard Data Structures. Many countries are collecting data on aspects of energy code implementation, and the collaborative sharing and comparing of data would be useful, for example in determining code compliance or effective performance measurement (as described in the section on code compliance checking systems). Having database structures that are standardised or at least similar would facilitate these analyses.

5 Forms of Collaboration

Project participants discussed a wide range of collaboration forms that could support governments in improving building energy code implementation and compliance. Table 2 summarises those forms that would be particularly helpful as articulated by BEET 3 participants, with strong support for the following forms:

- Developing a planned web portal to facilitate exchange and collaboration (see Section 6).
- Conducting webinars on specific topics as a low-cost way to share information and begin to build further collaborative efforts, as appropriate.
- Establishing a network of experts to answer questions and discuss issues.
- Sharing experiences, data, and methodologies through a best practice guide.
- Conducting collaborative projects, especially to foster mutual learning in emerging areas.

Table 2. Forms of Collaboration

Form	Description	Why Would This Form Be Helpful?
Web Portal	Categorised information from which experts could draw	• Could include document exchange and easy sorting of key information
Webinars	Sharing of targeted information on a given topic of mutual interest	• Provides information on topics of general interest • Can include people located far from one another • Can be targeted and interactive • Can be a way to explore the value of further collaboration
Network of Experts	Designated experts to answer questions or discuss issues with those who have less experience or to share information with experts in other countries	• May build collaborative relationships and provide needed information • Provide a forum to share information on technical topics where experts rarely know their international counterparts • With designated experts, may lessen the burden on government experts whose primary responsibility is domestic policy
Best Practice Guide	Guidance documents with broadly relevant information and country experiences (e.g., an overview of methodologies to analyse new code measures for cost effectiveness; guidance on working with utilities and third parties on code compliance; and details of how to develop and test software for robustness and user-friendliness)	• Could be posted on the web portal and made available to many countries • May be useful for a range of countries with different experiences • Can help countries gain ideas in specific areas where they may be able to improve compliance
Collaborative Projects	Agreement to provide resources and participate in specific projects with products that can be used by all	• May include data collection, focused reports, and the development of open source programmes or other tools • May provide high-quality products at lower costs to each partner
Technical Assistance	Typically one-way training, consultation, or sharing of data or experiences; may include training for trainers	• Highly beneficial to those assisted • May reduce the burden on government officials with competing responsibilities
Monitoring/Sharing of New Developments	Compiling and reporting news on countries' building energy codes; may take the form of a newsletter	• Potentially of broad interest • Could help build international collaboration

6 Development of a Web Portal

As part of the BEET 3 project, a web portal is in development with a range of collaborative capabilities of interest to project participants. The portal would reside on the website of the Global Buildings Performance Network (GBPN): www.gbpn.org. Recognising that a number of online resources exist for general information on building energy codes,[1] the current focus is on providing new information on implementation of building energy code systems according to specific topics of interest highlighted by participating governments, such as the history and scope of the code, the institutional arrangements for implementation, supportive tools and capacity building, enforcement mechanisms, and systems to test and rate building materials (see Appendices B–D). Information will be searchable by topic and by country, as recommended by project participants. In addition, the portal will either host or provide links to websites, relevant reports, and other building efficiency resources as determined by users.

Building the web portal within the www.gbpn.org knowledge platform will enable search strategies (such as keywords and brief summaries) for users looking for information on a given topic and has the potential for translation capabilities. The web portal will initially also provide a directory of experts in building code implementation by country and a web forum.

Beyond the BEET 3 project, participants affirmed that the web portal could be an important tool for international collaboration and advocated its development in several areas: as a document exchange space, with advanced search strategies and possible multi-language capabilities for categorising data; as a forum for comments and exchange of views; as an online space to connect with a community of experts available for consultation; and as a possible repository for software and other tools. The portal could also evolve to reflect changing priorities for international cooperation. Feedback from countries also indicated interest in the portal enabling sharing of policy best practices and lessons learned, with links to regional resources for policy makers and implementers. The scope and potential development of the portal is summarised in Table 3.

1. Examples include IEA's Building Energy's Efficiency Policies (http://www.iea.org/beep/), the EU BUILD UP Skills initiative (http://www.buildupskills.eu/en), and the Building Codes Assistance Project's Online Code Environment & Advocacy Network (OCEAN) (http://energycodesocean.org/).

Table 3. Web Portal Scope and Potential Development

Stage 1: Delivered as a BEET 3 Outcome	Initially, the portal will include: • Information on countries' code history and scope; code development; code implementation; compliance and enforcement; training and education; and building materials testing, rating, and labelling • Resource Library with links to reports and web resources • Expert Group contacts page • Web forum function enabling registered users to post comments, questions, and responses • Search functionality by topic, country, or key word
Stage 2: Potential Development	The portal could be further developed to include: • Best-practice guide or toolkit; webinar presentations; translations; expert networks forum; additional links to resources for code design, implementation, and compliance • Accessing expertise and convening stakeholders and decision-makers • Matchmaking between funding opportunities and project implementers • Capacity building and education tools and materials • Index of regional, national, and sub-national policy support programmes, networks, and information

7 Conclusions

The IPEEC Building Energy Efficiency Taskgroup (BEET) has identified opportunities for collaborative work to support countries in realising the massive energy savings potential in the building sector. International collaboration could support countries in taking concrete actions in the following priority areas: code compliance checking systems; measuring performance; compliance software and rating tools; incentives; amongst other areas.

With the support of governments, the IPEEC BEET and its partners could facilitate country actions in these areas through recommended forms of collaboration, including the following:

- **Web Portal:** Expand the BEET web portal on building energy code implementation with tools, resources, and educational and training materials.[1]
- **Webinars:** Establish a codes-focused webinar series on key collaboration areas for code implementation and compliance to share knowledge, experience, and lessons learned.
- **Network of Experts:** Further build a network of experts in code implementation to share best practices and provide expert guidance to one another and to other policy officials.
- **Best Practice Guide:** Develop a best practice guide on options for code development, implementation, compliance, and enforcement programmes.
- **Collaborative Studies:** Conduct collaborative studies on code topics of mutual interest, such as measuring building performance compared to the code and evidence-based studies on different compliance approaches.

MEF and G20 member and guest governments could join and expand the current IPEEC BEET work on building energy codes by providing technical staff to work collaboratively on the focal areas of greatest interest and to advance the forms of collaboration that government experts identified as helpful and impactful.

National and subnational governments are ultimately responsible for adopting and implementing building energy codes. However, where appropriate,

1. Within the European Union (EU) are two existing efforts. (1) The BUILD UP initiative, established by the EU Commission in 2009 to support EU Member States in implementing the EPBD. It serves as a web portal to exchange best working practices and knowledge and to transfer tools and resources. http://www.buildup.eu/. (2) The Concerted Action EPBD, a forum launched by the Commission to promote dialogue and the exchange of best practices between countries in reducing energy consumption in buildings. http://www.epbd-ca.eu/.

international collaboration can play a critical role in supporting governments in advancing their own priorities, through the sharing of policy best practices, improving analytical capabilities, and providing other resources that accelerate and maximise the benefits of building energy codes.

This report has explored specific areas in which international collaboration can foster implementation activities related to building energy codes. Learning with and from each other, countries can implement more effective programmes and strategies and thereby speed progress toward realising the many benefits of energy-efficient buildings.

8 Glossary

Adoption. The enactment of laws or regulations that make compliance with the energy code mandatory.

Benchmarking. Establishing a standard or point of reference for building energy consumption.

Building energy codes. Standards for minimum levels of energy efficiency in buildings as they are designed and built. Building energy codes typically cover systems such as the building envelope, lighting, heating, air conditioning and ventilation, hot water heating, and certain mechanical systems.

Building energy simulation. The process of estimating the energy usage of the building from a model, using a computerised system. Building energy simulation is the basis of performance-based codes. See also "performance codes" and "performance approach."

Building rating system. A process that develops a rating for a building's performance relative to other buildings. Building rating systems may be focused solely on energy aspects of a building or include also sustainable design aspects, such as green building materials and water efficiency. See also "green building materials."

Code compliance. Whether and to what extent buildings adhere to the provisions of an energy code. See also "compliance."

Code cycle. The frequency of revision to codes or standards. Cycles may include a series of calls for proposed revisions, public hearings, and votes on the content of new codes. See also "code development" and Appendix B for more information.

Code development. The process of creating and updating a code. It typically includes analysis, drafting, public comment and revision before an updated code is finalised.

Code officials. Persons representing a jurisdiction that has adopted a code and who are charged with enforcing the code. Third parties may perform the functions of code officials in some jurisdictions. See also "enforcement."

Compliance. The adherence of buildings to the provisions of the code.

Compliance checking system. Systems or processes for determining whether or not buildings comply with a code. These systems may be manual or automated, depending on the availability of the compliance information and the compliance checking system user. These systems may be used by code officials during enforcement or by designers as a self-check on their designs. See also "compliance software and tools," "enforcement," and "code official."

Compliance software and tools. Software or tools that may be used to demonstrate that a building design complies with a code. Software may range from relatively simple automated checklists to more sophisticated software that performs calculations allowed in codes.

Construction inspection. Typically the second step in enforcement, in which a code official visits a construction site to ensure that construction complies with the code and agrees with the building plans that were reviewed. See "code official," "plan review," and "compliance."

Enforcement. A process by which compliance is assured by code officials. Enforcement typically consists of at least two steps—plan review and construction inspection. See "enforcement," "code official," "plan review," and "construction inspection."

Green building materials. Those components of a building that are judged to have "green" or sustainable qualities. Green building materials may include materials that are made from recycled materials, are locally grown or produced, are grown or created in an approved sustainable way, or have a desirable property like low volatile organic compounds.

Implementation. The process of putting a regulation, law, or plan into effect. The implementation of building regulations includes establishing administrative structures to enforce the code, the development of labs for the testing of materials to ensure that the code can be enforced, and training and development of key stakeholders.

Material labelling. The process of affixing a label or supplying other documentation about a material that will allow the properties of the material as tested to be reviewed by a code official. See also "code official," "enforcement," "material rating," and "material testing."

Material rating. The process of determining the regulated properties of a material based on the physical properties identified during testing. See also "material labelling" and "material testing."

Material testing. The process of determining the physical properties of a material. See also "material labelling" and "material rating."

Outcome-based code. Standards requiring that buildings do not exceed a maximum annual operating energy use, which includes the actual operation of the building. This pathway demonstrates whether actual energy efficiency is achieved by requiring a one-time or ongoing reporting for compliance verification.

Performance approach. Setting of code requirements based on total simulated performance of a building in terms of energy usage or some related characteristic.

In a performance approach, the code specifies the simulation rules. Depending on how the code is written, building designs can be compared to a reference building or to a fixed energy use or a carbon dioxide (CO_2) index. Codes may contain multiple approaches that will all lead to compliance (see also "prescriptive approach" and "trade-off approach"). A performance approach provides designers with significant flexibility in how they meet the code requirements, although they require more sophisticated tools and skills.

Plan review. The first step in enforcement, in which a code official inspects the plans submitted for a building to ensure that the plans contain all the information necessary to determine compliance and that the plans do in fact demonstrate the building as designed will comply with the code. See also "enforcement," "code official," and "compliance."

Prescriptive approach. Code that defines the individual metrics that various building components must satisfy. Prescriptive requirements provide specific rules on individual building components, for example how much heat windows transmit, typically expressed in tables.

Reference building. A design that just meets the mandatory and prescriptive requirements of an energy code. The concept of a reference building is used in performance-based approaches such as ASHRAE Standard 90.1's Energy Cost Budget (ECB) method where compliance with the code may be demonstrated by comparing the estimated annual energy cost of a proposed design with the estimated annual energy cost of a reference building.

Third parties. Individuals or companies not affiliated with the building in any way. See also "third-party verification."

Third-party verification. Assessment of compliance provided by an independent reviewer not affiliated with the building in any way.

Trade-off approach. A method in some codes that allows a user to trade off between various prescriptive requirements in the code. The trade-off is usually based on the concept of "equal estimated energy" in an energy code. An example trade-off might be a building that has more than the minimum required amount of insulation in a roof to compensate for slightly less than the required amount of insulation in a wall.

Very low-energy buildings. Buildings that use relatively low amounts of energy. Includes the terms "nearly-zero buildings," "net zero-energy buildings," "net zero-ready buildings," and "ultra-low-energy buildings."

Appendices

9

Appendix A. Project Process and Interest in Areas of Collaboration

Experts from the Global Buildings Performance Network (GBPN) and Pacific Northwest National Laboratory (PNNL), together with other nongovernmental building energy efficiency experts, developed an initial list of collaboration areas and then sought input and feedback from government representatives of MEF and G20 member and guest governments. The initial list included code compliance checking systems; measuring performance; compliance software and rating tools; incentives; and materials testing, rating, and labelling.

Representatives from 16 MEF and G20 member and guest governments participated in phone calls with GBPN and PNNL in December 2014 and January 2015 focusing on the following questions: (1) Does international collaboration currently exist in these areas and, if so, could those existing platforms for collaboration be enhanced or expanded? (2) What other forms of international collaboration could help to strengthen these areas? (3) Are there any aspects of code implementation and compliance that should be considered for international collaboration that we have not yet included? Following the calls with government representatives, GBPN and PNNL rated the interest level (high, medium, or low) of governments for each collaboration area (see Table A.1.). In a couple cases, there was not enough feedback to assign an interest level.

Countries also raised and expressed interest in the following areas: education and training; code drafting methodologies; and data standardisation.

Table A.1. Interest Levels of Government Representatives in Potential Areas of Collaboration

	No. of responses	Interest Level		
		High	Medium	Low
Code Compliance Checking Systems	14	7	7	0
Measuring Performance	14	8	2	4
Compliance Software and Rating Tools	14	9	1	4
Incentives	14	7	3	4
Materials Testing, Rating, and Labelling	14	3	5	6

Appendix B. Code Revision Schedule in Different Countries

The regular revision of codes can help improve the code over time as jurisdictions learn from implementation and as technology improves. A clear schedule also can provide stakeholders with time to adapt to changes. The following participating countries have reported some approach to code revision schedules, as shown in Table B.1.

Table B.1. Countries with Building Energy Code Revision Schedules

Country	Schedule
Australia	Irregular
Canada	Every 5 years
China	Irregular but increasing in frequency, partial revisions of certain standards
France	Roughly every 6 years, in coordination with the EU
Germany	Ad hoc, in coordination with the EU
India	Irregular, next in 2017/18
Italy	Ad hoc, in coordination with the EU
South Korea	Every 4 years
Spain	Ad hoc, in coordination with the EU
Turkey	Yes, in the National Climate Change Action Plan
United Kingdom	Irregular, next in 2016
United States	Every 3 years

Appendix C. Role of Governments in Code Implementation

The jurisdictions responsible for building code development and code enforcement are often operating at different levels of government. In order to help clarify where collaboration might be most beneficial, participating countries were asked about the role of different stakeholders involved in their codes process. As Table C.1 below shows, building codes are commonly developed by national governments and enforced by local jurisdictions. One suggestion on adapting international collaboration to the needs of a broad spectrum of jurisdictions is to identify intermediary organisations in each country that can help bring together the needs of local jurisdictions and translate international experience into the local context.

Table C.1. Government Roles in Codes Process

Country	National	Region/State/Province	Local Jurisdiction
Australia	Develops performance requirements of National Construction Code	Adopts code; adapts national code to state requirements, including adaptations to climate zones	Enforces code
Canada	Develops code; provides tools, training and resources; issues model building codes	Adopts code; adapts national code to state requirements, including adaptations to climate zones	Enforces code
China	Develops and adopts code; leads strategic planning processes on macro-level construction; manages policies on national building energy efficiency; provides incentives	Adapts national code to state requirements, including adaptations to climate zones	Enforces code
France	Develops and adopts code; supports accreditation; coordinates with the EU	None	Enforces code
India	Develops code; provides training and resources	Adapts national code to state requirements, including adaptations to climate zones	Adopts and enforces code
Italy	Provides technical support for code development and accreditation; provides incentives; develops programmes to harmonise regional codes; coordinates with the EU	Adopts code and technical guidelines; supports accreditation	Enforces code
Japan	Develops and adapts code; provides oversight, coordination and training	None	Enforces code
Mexico	Develops code; provides training and accreditation; reviews plans; issues permits		

Table C.1 continued

Country	National	Region/State/Province	Local Jurisdiction
Russia	Develops and adopts code; provides oversight and coordinates amongst enforcement agencies	Adopts local codes (in a few jurisdictions); offers training and support	Enforces code
South Africa	Develops and adopts code and technical regulations; provides training	None	Enforces code
South Korea	Develops and adopts code; provides assistance to local governments	None	Enforces code; issues building permits
Spain	Develops and adopts code; coordinates with the EU	Determines forms of inspection	Enforces code; may determine forms of inspection
Turkey	Develops and adopts code and regulation; offers training and energy auditing; raises public awareness	None	Enforces code
United Kingdom	Develops and adopts code and regulation; provides tools, training, resources and incentives	None	Enforces code (sometimes with assistance of third party assessors)
United States	Develops code and regulation; offers tools, training, resources and incentives	Adopts code	Enforces code

Appendix D. Code Compliance Checking

Checking compliance with energy provisions of building codes is critical to achieving energy efficiency goals, but local priorities and resources may limit the extent of these checks today. As a result, MEF and G20 governments consistently reflected on the need to boost implementation and enforcement efforts domestically. Table D.1 describes how different countries handle compliance checks both at the design and construction phases. The table also shows that compliance checking during design is more common than checking on-site during construction. In many countries, compliance checking during construction is not systematic, but rather occasional and random.

Table D.1. Parties Responsible for Compliance Checking

Country	Design Phase	Construction Phase
Australia	Local government or third party, varies by state	Local government or third party, varies by state
Canada	Local government or third party	Local government or third party, varies by province
China	Local government and third party	Local government and third party
France	Third party	Third party for blower door tests; occasional inspections of other installations
Germany	Third party, occasional inspections by local government	None or occasional in most states, third party in other states
India	Local government or third party, but inspections are rare	Local government or third party, but inspections are rare
Indonesia		None
Italy	Local government and third party	Local government and third party, varies by region
Mexico	Local government or third party (in situations where the code applies)	None or sporadic
New Zealand	Local government	None
Russia	Third party with some review by local government	None
Singapore	Third party	
South Africa	Local government and third party	Occasional inspection by local government
South Korea	National government institute	
Spain	Local government	Local government or third party
United Kingdom	Local government and third party	
United States	Local government	Local government or third party, varies by state

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