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Economic Cooperation

Opportunities for Collaboration to Improve Building Energy Codes in APEC Economies

APEC Energy Working Group

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The Global Buildings Performance Network (GBPN) in collaboration with the Centre for Urban Transitions, Swinburne University of Technology, Melbourne, Australia.

Authors:
Professor Peter Graham, Executive Director GBPN and Deputy Director of the Centre for Urban Transitions, Swinburne University of Technology pmgraham@swin.edu.au

Jennifer Witheridge, Centre for Urban Transitions, Swinburne University of Technology

Dr. Sean McNelis, Centre for Urban Transitions, Swinburne University of Technology

This Paper has been produced for:

Asia-Pacific Economic Cooperation Secretariat
35 Heng Mui Keng Terrace
Singapore 119616
Tel: (65) 68919 600
Fax: (65) 68919 690
Email: info@apec.org
Website: www.apec.org

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1. Executive Summary

1.1 Context

APEC economies continue to engage positively in the development and implementation of building energy codes as a key policy strategy for achieving energy savings and reducing greenhouse gas emissions. This discussion paper draws from recent published research on building codes activity globally and in APEC economies, and new interviews conducted with policy makers in eight participating APEC Economies in the Asia-Pacific[1] to provide a summary of best-practices in building energy codes, a landscape analysis of building energy codes in the Asia-Pacific and an analysis of common issues and opportunities for collaboration among APEC economies in the Asia-Pacific.

1.2 Project objectives and outputs

This report aims to support discussions at a strategic workshop with the participating economies on a potential Asia-Pacific Building Codes Forum. It will be held in Singapore on 7 July 2017.

This workshop will aim at facilitating discussions on:

- The findings of this study, with a view to confirming or refining the key findings;
- Common challenges and opportunities for collaboration, with a view to prioritising potential future actions;
- The potential for and interest in the establishment of an Asia-Pacific building codes forum, including:
    - Goals;
    - Ownership and leadership;
    - Potential future agenda, based on potential areas for knowledge-exchange outlined in this discussion paper;
    - Immediate actions.

The outputs from this workshop will be summarised into a final briefing paper to be presented to the APEC Building Energy Efficiency Incubator stakeholder forum to be held on 8 August in Jakarta.

1.3 Potential for an ongoing Asia-Pacific Building Codes Forum

The priorities for collaboration identified in this study reinforce the findings of previous studies into priorities for international collaboration on building energy policies and codes. What emerges is a confirmation that exchange of best practices between peers, training and capacity building are sought after by building energy policy makers. While there are a number of platforms available to, or being participated in, by APEC economies, there is no dedicated platform or forum specifically on building energy codes for the Asia-Pacific region. That said there are opportunities to bring organisations such as UNEP, GBPN, SE4All, ASEAN, the IEA and IFC that are active in this space together to resource such an initiative.

[1] The participating economies are Australia; China; Indonesia; Malaysia; The Philippines; Singapore; Thailand; and Viet Nam.

Establishing an Asia-Pacific Building Codes Forum could facilitate collaboration, knowledge sharing and capacity building to improve the design, implementation, effectiveness and ambition of building energy codes in the region. There is therefore a rationale for creating an APEC Asia-Pacific Building Codes Forum. Appetite from economies in the region to set up such a forum as well as its specific actions and intended impact are yet to be discussed and determined.

1.4 Key findings

Current Status and Best Practices

APEC economies are in different stages of building energy code development. Below is an overview of how participating economies are currently performing in terms of the best practices for building energy codes identified by the Global Buildings Performance Network (GBPN). These findings are discussed in more detail in Section 3 in relation to five best-practice criteria:

- Holistic approach;
- Dynamic process;
- Implementation;
- Technical requirements;
- Overall performance.

- *Holistic approach*

  Best practice codes include a package of measures designed to support and reinforce mandatory requirements. All eight participating economies have developed policy packages including mandatory energy performance requirements in their building codes aligned with voluntary and market-based measures such as green building standards and certification programs. Both performance and prescriptive approaches are commonly available as compliance pathways in APEC economies.

  Major renovations and extensions are often included in best-practice energy codes, but for many of the APEC participating economies, meeting energy code requirements in renovations is currently voluntary, or the code only applies to buildings above a certain size or energy usage, thus excluding a large proportion of the existing building stock.

- *Dynamic process*

  Globally, setting jurisdictional targets to achieve zero net energy or positive energy buildings using mandatory codes is best practice. Among participating APEC economies, only Singapore is working towards putting in place a plan for progress to net zero energy buildings. Among all APEC economies Japan has zero energy targets for public and commercial buildings, and Canada has targets for new residential buildings. The United States has goals for all federal buildings to be zero energy, and some states have more wide-reaching zero energy or decarbonisation goals.

  Most APEC economies have energy performance requirements either incorporated into building codes, or as separate codes or laws. The use of voluntary rating programs is also widespread. However, scheduling regular revisions of energy performance requirements is not common. This hinders capacity building for, and investment in, very low-energy buildings.

- *Implementation & Enforcement*

  Best practice in building energy code implementation includes robust enforcement and compliance systems, such as mandatory certification and disclosure of energy performance, and policy packages that support code enforcement including voluntary rating programs, financial incentives, capacity building and training and demonstration projects.

  Commercial buildings are covered by mandatory energy performance requirements in 14 APEC economies and by voluntary requirements in 4 economies. Energy performance requirements are mandatory for residential buildings in 9 economies and voluntary in 10 economies. These requirements are applied predominantly to new construction. Expanding energy performance requirements to residential buildings and building renovations is not yet common and needs to be supported.

  All participating APEC economies support voluntary rating schemes that include comprehensive environmental performance measures. This is an important step towards implementing more comprehensive energy uses and functions in mandatory building codes. Mandatory building energy rating schemes are yet to be fully implemented in most participating APEC economies.

  Effective compliance with and enforcement of energy provisions of building codes remains a common challenge in participating economies. Compliance checking is very common at design and construction phases of new building projects. However, pre-occupancy and post-occupancy compliance checking is still not common among participating APEC economies. This hampers the monitoring of actual performance and the ability to evaluate the impact of building energy codes on building energy demand and energy savings. More training and capacity building is also required to help participating economies develop roadmaps for future changes in codes, and to support local officials to improve code enforcement and compliance.

- *Technical requirements*

  The technical requirements commonly covered in building energy codes within APEC include the building envelope, energy efficiency, HVAC and lighting. Codes adopted in some US States, Singapore and China include additional measures. Many APEC economies also include voluntary implementation pathways for additional measures within their codes, or support voluntary rating schemes that include comprehensive measures.

  The structural coverage of building codes in APEC economies often includes a number of building categories that represent a greater diversity of building types, particularly for residential buildings, or industrial buildings. Auditing or documenting existing building stock is crucial for determining structural coverage and monitoring operational energy performance, and may reveal traditional green building forms and practices which have potential to be included in future code development. Auditing and monitoring is still not common in most APEC economies, and less so for traditional and residential buildings.

- *Overall performance*

  The impact of building energy codes on actual energy performance of buildings should be monitored and reported regularly. Indicators such as on-site energy demand, primary energy demand and GHG emissions should be measured to determine whether the code is being effective in reducing building energy use, improving energy efficiency and reducing climate change impacts of the building sector.

  This is generally poorly covered internationally. Among APEC participating economies Singapore includes post-occupancy energy auditing within their compliance checking approaches and Australia has adopted a mandatory energy performance disclosure program for commercial buildings. Jakarta Indonesia is including post occupancy energy audits in its Green Building Code.

Common Issues and Opportunities for Collaboration

The responses by participating countries to questions of challenges and priorities for collaboration to improving codes reinforce the findings of previous studies into priorities for international collaboration. The research found the following common issues need to be addressed in participating economies:

- Developing strategies for regular code upgrading including regular schedules for code reviews and increasing energy performance requirements towards very low, net zero or positive energy buildings;
- Extending the structural coverage codes to more comprehensively encompass residential building energy performance, and renovation projects;
- Post occupancy evaluation or auditing of operational building energy performance and integration of this into rating and disclosure policies, and
- Enforcement of and compliance with building energy code requirements, including the use of incentives and penalties.

In terms of frequency of response, respondents from economies prioritised the following issues (in rank order):

1. Support for setting long term policy goals and performance targets.
2. Training and capacity building in code design, implementation, compliance and stakeholder engagement.
3. Support for developing or extending building energy codes and standards.
4. Support for developing or expanding energy performance rating, labelling and disclosure.
5. Support for introducing mandatory codes, improving stakeholder engagement and collecting compliance data.

2. Introduction

2.1 Why Building Energy Codes

In December 2015 in Paris, France, the nations of the world agreed to act to keep global warming to less than 2^{o}C above pre-industrial levels and to aim to limit temperature increase to 1.5^{o}C to minimize the risks and impacts of climate change. Achieving this requires reducing greenhouse gas emissions by 60% by 2050 compared to 2012 levels (IEA 2016).

Reducing energy demand in the building sector, which contributes about 30% of global energy-related GHG emissions, is critical to meeting this goal. Yet building energy demand is projected to increase by about 50% by 2033, driven substantially by growth in energy demand for space cooling (GABC 2016).

If the Paris Agreement goal of keeping global warming well below 2^{o}C is to be achieved, the projected growth in building energy demand must be entirely avoided and limited to 2013 levels by 2030. This can be achieved through mainstreaming near or net zero energy or positive energy buildings for new construction, and significantly increasing deep energy saving renovations of existing building stock (IPCC 2014; GABC 2016).

While many countries have now demonstrated the technical feasibility of such approaches, in a highly fragmented sector such as buildings, moving to mainstream adoption requires a policy commitment to transforming to low carbon construction markets with improved adoption and enforcement of ambitious building energy codes. Well-designed and implemented building energy codes are recognized as among the most cost efficient and effective policy measures for mitigating building energy-related greenhouse gas emissions. Countries that have well implemented building energy codes have also demonstrated progressive reductions in the intensity of building energy use over time (IPCC 2014; GABC 2016).

Economies that have implemented building energy codes have also experienced important co-benefits such as local job creation, increased energy productivity and security, and improved urban air-quality (IEA 2013). Furthermore, modelling indicates that early investment in ambitious near or net zero building energy policies can provide significant long-term monetary returns to national economies. However, investing in less ambitious policies may never provide a positive return (Urge-Vorsatz et al. 2015). Establishing and effectively implementing building energy codes therefore play a key role in achieving both Nationally Determined Contributions (NDC's) and Sustainable Development Goals (SDGs).

2.2 Building Energy Codes are an International priority

The economic, social and environmental benefits of ambitious, well implemented building energy codes and supporting policies are well documented. This may account for the high-level of awareness and policy activity on building energy performance in local, regional and national economies. For example, 88 countries have mentioned the buildings and construction sector in their NDC's, while more than 3,000 municipalities and over one hundred-business organizations have registered buildings-related commitments on the UNFCCC NAZCA database (GABC 2016; UNFCCC 2017). Mandatory and/or voluntary building energy codes now operate in 60 countries (GABC 2016). Among jurisdictions in APEC economies, 17 include minimum energy performance requirements in their building codes for new commercial and/or residential buildings.

Despite the high level of engagement however, the potential for building energy codes to achieve their energy savings potential is often undermined by a range of common issues such as:

- Not aligning codes with supporting policies such as energy performance certificates, incentives and voluntary rating schemes
- Poor code implementation, enforcement, revision planning and compliance.
- Lack of local industry capability to design and/or construct compliant buildings, and
- Lack of monitoring and data gathering to verify building energy performance during operation.

There are however a number of best-practice jurisdictions within APEC and globally that have effectively set near or net zero performance targets, established revision cycles that communicate future increases in code stringency, and provide policy packages that:

- Support industry to build capacity,
- Provide incentives to build to future code requirements,
- Promote high-performance through energy rating and labelling programs, and
- Monitor and report on progress and barriers.

Sharing these best practices as a way of overcoming local barriers, and learning from peers is considered a high priority for economies within APEC and beyond (Chong 2013; IPEEC 2014).

2.3 Analytical Framework

This discussion paper provides a summary of best-practices in building energy codes, an analysis of building energy codes in Asia-Pacific, particularly in the eight participating economies (Australia; China; Indonesia; Malaysia; The Philipppines; Singapore; Thailand; and Viet Nam), and an analysis of common issues and opportunities for collaboration among APEC economies in the Asia-Pacific.

The research involved a comprehensive literature review of recent studies of building energy code development and implementation in the Asia-Pacific region. Interviews were conducted to provide a more detailed analysis of the design and implementation of codes in Australia; China; Indonesia; Malaysia; The Philippines; Singapore; Thailand; and Viet Nam.

In each participating economy, building energy codes have been studied in context in order to take into consideration the influence of:

- The profile of the construction market;
- Code development approaches;
- Governance and implementation arrangements;
- Supporting policies and Initiatives.

2.4 Possible approaches to energy efficiency building codes

In this report building energy codes are defined as a set of rules that specify a minimum level of requirements for energy consumption, intensity or efficiency of buildings which are adopted and/or enforced by, or on behalf of a government entity (Chong 2013). Building codes can be designed to be implemented as either prescriptive, performance-based, simple trade-off codes, or outcome based codes.

- *Prescriptive Codes*

  Specify requirements for key elements such as wall and ceiling insulation, window and doors, roofs, foundations, heating, ventilation air-conditioning, equipment efficiency, water heating, lighting fixtures, and controls. Compliance with these codes is commonly assessed by checking project designs and specifications against the list of prescribed requirements.

- *Simple Trade-Off Codes*

  Typically allow for trade-offs between similar building components. For example, less efficient insulation for more efficient windows in the building envelope.

- *Performance Codes*

  Specify a minimum required level of energy consumption or intensity for the whole building. They require energy modelling to be conducted at design stage. Compliance is commonly checked by comparing the modelled energy performance of the design with a reference building of the same type.

- *Outcome-based Codes*

  Requires demonstration of buildings achieving code required performance in operation. Compliance is typically possible through energy performance certificates or with energy disclosure policies.

  Most economies provide several options for code compliance, including prescriptive models and performance based models, to suit the local construction industry and modes of development (IEA 2008).

Table 1: Typical Code Compliance Approaches and How They Work

Approach	How it works	Advantages and disadvantages
Prescriptive	Prescriptive requirements provide specific rules on individual building components, for example how much heat windows transmit, typically expressed in tables.	Are simple to understand and apply, and can be a low-cost option. Can limit innovation in building design, or flexibility in the building. Sometimes prescriptive values are set so that the building exceeds minimum performative standards, but they may also restrict stringent energy reduction requirements. Software tools and complicated calculation methods are not required.
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).	Simple to apply, often basic ratings software or simple spreadsheet calculations tools are used. Improves flexibility of design, and can lead to building cost savings. May incentivise meeting requirements rather than optimising energy use.
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).	Allows for flexibility in design, products, systems and construction, and enables freedom during the design and construction processes to determine how energy performance standards are achieved and to incorporate current commodity and market conditions. Tools may vary in complexity including minimum requirements for HVAC and building parts to including all building systems and renewable energy. Expert knowledge is required to use simulation software, and rules must be well defined.
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.	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). Usually applied with a mix of prescriptive and performative options. Is reliant on product and materials testing and rating schemes being established.
Outcome-Based Code	This is a new concept and there are very few examples in place yet (New Buildings Institute no date). 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: Reproduced from IPEEC 2015a; Advantages and disadvantages sourced from IPEEC 2015a and IEA 2008.

3. Status and Best Practices in Building Energy Codes

Because of the large variation in market contexts within which building codes are deployed, it is difficult to define generalizable best practices. However, there is a consensus among experts on the elements of building energy policies that are necessary for building energy codes to be most effective in achieving energy savings and mitigating GHG emissions. The extent to which specific building energy codes meet these criteria, and the relative importance of each criteria within a specific market needs to be determined based on local market conditions, and economic, social and environmental goals.

3.1 An Integrated Building Energy Policy Package

In general, jurisdictions that are achieving energy savings and improved building energy performance have building energy codes as a component of an integrated building energy policy package that involves:

- **Regulations** that set and enforce mandatory minimum performance requirements;
- **Incentives** that help stimulate demand or reward the achievement of higher than minimum performance; and
- **Capacity Building**, awareness raising, awards and recognition for achieving very high building energy performance such as net-zero or positive energy, zero-emissions or more holistic green building standards.

Best-practice policy packages might include:

- A performance-based building energy code that effectively enforces an ambitious but achievable mandatory minimum energy intensity requirement for total energy demand, establishes a schedule of regular revisions, and commits to a timetable of incremental increases in mandatory minimum performance toward near or net-zero energy, or positive energy performance;

- Incentive programs such as preferential lending, or low interest rate ‘green’ loans, third-party verification of energy renovation programs, property tax discounts, subsidies for energy efficient technologies;

- Voluntary ‘green’ or ‘sustainable’ rating schemes or model codes that recognise projects that achieve net-zero or positive energy performance through energy rating and labelling programs, and which offer training to enable industry to build to the performance standards necessary to be on the 2^{o}C pathway;

- Aligned energy efficiency standards for appliances, building equipment and components such as windows, and

- Capacity building and training to ensure the construction industry undertands the energy provisions of the code and has the capability to comply with it, and that officials are able to enforce compliance.

3.2. International and APEC Building Energy Codes - Overview

This section provides an overview of the approaches to best practice used internationally and in APEC economies. GBPN's Best Practice Criteria for building energy codes are used to structure the discussion. Focussing specifically on best-practice building energy codes, the Global Buildings Performance Network (GBPN) has identified the following criteria:

Diagram 1: Best Practice Criteria for Building Energy Codes for New Construction

Sources: GBPN 2013, 2103b, 2013c

3.2.1 Holistic Approach

A holistic approach to building codes and policies includes taking into account how each section or code requirement contributes to the total energy performance of the building. This is influenced by (i) the building code approach (performative, prescriptive, or outcomes based) and (ii) the extent to which all energy efficiency measures, and renewable energy are included.

Building Code Approach

Prescriptive and trade off codes are simple and easy to apply but require good materials and products rating standards to be fully successful. Performance-based models allow for flexibility and freedom to innovate above minimum energy efficiency requirements (GBPN 2013, IPEEC 2015a). Performance based models may also allow trade-offs to be made between certain building features; for example, offsetting a poorer performing building envelope with high performing HVAC and other building systems, resulting in poor building energy performance on occupation (IEA 2013).

A best practice approach uses a combination of prescriptive and performative models where minimum prescriptive requirements for separate building components are set, and whole of building performance criteria minimums are set higher than the cumulative prescriptive minimums (IEA 2013). Outcomes based approaches provide a mechanism for ongoing building energy performance to be verified periodically, and has the potential to engage building residents and users in optimising the energy efficiency features of the building. The availability of software and rating systems and the capacity of qualified experts in both the design and compliance checking processes need to be considered when reviewing and developing code compliance approaches. For all approaches, adequate training and education programs are an essential for code compliance (GABC 2016, IEA 2013, IPEEC 2015a).

In all participating APEC economies, the structural coverage of building energy codes includes mandatory performance requirements for new commercial buildings. However, energy codes for residential buildings remain predominantly voluntary, despite the residential sector being a more significant driver of building energy demand among APEC economies (GABC, 2016).

Most building codes in participating APEC economies also apply mainly to new buildings, however, building renovations also need to be included in best practice codes. While some developing economies experience much higher growth in new buildings, in established economies existing buildings make up most building stock. In Australia for example, new buildings add only 2% of the building stock annually (NHSC 2013), so improving the existing building stock has the potential for significant, ongoing energy reductions. In Australia, all major residential renovations and building extensions are expected to meet the minimum 6 star code requirements calculated on building envelope and lighting (VBA, 2017). Major renovations and extensions are often included in energy efficient codes, but for many APEC economies meeting the code minimums are voluntary, or the code only applies to buildings above a certain size or energy usage – excluding a large proportion of the existing building stock.

Inclusion of all energy, energy efficiency and renewable energy
Best practice is for building energy codes to be mandatory for all building types with no or few exemptions. Energy consumption requirements in the code must be set appropriately for each building type and climate zone (GBPN 2013, IEA 2008, IPEEC 2015). Commercial buildings include: offices, retail and wholesale, hotels, hospitals, educational buildings and public buildings. Often the allowable energy consumption levels are determined both by the type of building, as well as the floor area and building envelope (GBPN 2013). Public buildings or government buildings are often a separate category, enabling governments to lead by example and set higher energy efficiency requirements (GBPN 2013).

To be energy efficient, buildings need to be designed or modified to suit local climatic conditions. APEC economies commonly develop codes adapted to different climatic regions and whether cooling or warming practices are required. For example, China has separate residential energy efficiency codes for four of its five climatic regions ranging from severe cold to hot summers and warm winters (IPEEC, 2015a).

In economies such as the Philippines, significant natural hazards in particular regions may need to be considered alongside climatic zones, and require developing energy codes that align with structural and safety codes (Foliente 2017). In economies where state, provincial or local governments adapt or develop codes, the codes may be developed with greater climatic zone emphasis; for example, the regulations in the states of Queensland (sub-Tropical to Tropical) and Victoria (Temperate) in Australia reflect the regional cooling or heating requirements respectively.

Auditing or documenting existing building stock is crucial for determining the most effective structural coverage for an energy code, and may reveal traditional building forms and practices that have potential to be included in future code development. Broad building categories with straightforward definitions simplifies the structural coverage in the code, and may make the regulations easier to apply.

3.2.2 Dynamic Process

The dynamic process refers to the code development and revision process, and setting clear future targets. Best practice jurisdictions articulate a roadmap to signal when increases in code stringency will occur, and provide incentive and voluntary programs to encourage builders to go beyond minimum performance requirements and begin constructing to future code requirements (Chong 2013; IPEEC 2015a; IPEEC 2014; GBPN 2017).

Most participating economies have well developed regulatory structures to include energy efficient requirements in building codes, and tailor different code development options that suit their existing building code regulations. However, many economies do not have regular, scheduled review processes for codes, nor have set long term energy savings or performance goals. To enable this to occur, economies need to commit to the continuous development of more stringent codes, dedicate the resources for regular revisions and, support code implementation and compliance.

Levels beyond minimum

Best practice energy efficiency codes have pathways or incentives to go beyond minimum codes to develop passive buildings where comfortable indoor temperatures are achieved without traditional heating or cooling systems, or low or zero net energy buildings. These building designs reduce energy use for heating and cooling by 50-90% can only be achieved by taking into account the climatic zone and specific siting of the building (IEA 2008 p. 65-6). Germany, Austria and Finland reference passive home standards in residential building codes for beyond minimum requirements (GBPN 2013).

All participating APEC economies have some form of policy measure in place to encourage developers and builders to achieve better than minimum code requirements. A common approach is to align a voluntary green building rating scheme with energy code compliance. This approach also enables consideration of non-energy related environmental performance issues such as water and resource efficiency to be considered and also often covers a more comprehensive range of building types. These ratings are commonly developed and implemented by industry or third-party organisations such as a local Green Building Council. Table 2 below summarises the local voluntary rating schemes being deployed in support of building energy codes in participating economies. International systems, such as USGBC's LEED and IFC's EDGE, also play a role in the APEC participating economies.

Table 2: Local Voluntary Ratings Schemes

Economy	Rating scheme	Organisation
Australia	Green Star	Australian Green Building Council
China	National Green Building Evaluation Standard (Three Star Standard)	Ministry of Housing and Rural and Urban Development (MOHURD)
Indonesia	Green Ship	Green Building Council of Indonesia
Malaysia	Green Building Index	Malaysian Green Building Confederation
Singapore	Green Mark	Building and Construction Authority (BCA) Singapore
Thailand	Thailand Rating Energy & Environment System (TREES)	Thai Green Building Institute
The Philippines	Building for Ecologically Responsive Design Excellence (BERDE)	The Philippines Green Building Council
Viet Nam	LOTUS	Vietnam Green Building Council

Zero Energy Target
Globally, best practice jurisdictions set national policy plans that include achieving zero net energy or positive energy buildings in appropriate building types. Mandatory energy performance requirements in codes are an important element of policy packages designed to implement such plans. For example, among APEC economies Japan has zero energy targets for public and commercial buildings, and Canada has targets for new residential buildings (IEA 2013). The United States has goals for all federal buildings to be zero energy, and several states have more wide reaching goals (IEA 2013, GBPN 2013). However, APEC economies participating in this project are yet to set net zero energy goals for the future development of their building energy codes.

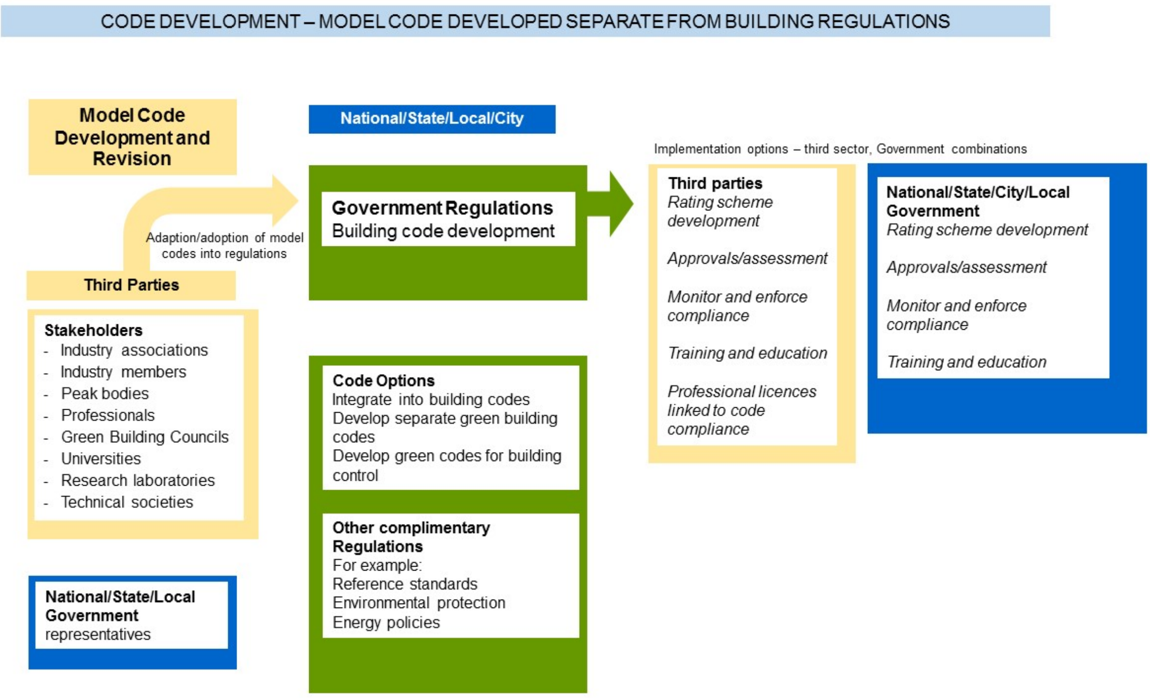
For building renovations, deep renovations (renovations which significantly reduce the building energy consumption (80% average) are considered to be best practice. Several programmes globally support deep renovation, particularly in Europe (IEA 2013). Renovations require adequate, mandatory building energy rating schemes so that the existing energy performance of buildings is known, these are yet to be fully implemented in participating APEC economies.

3.2.3 Implementation

Implementation of building energy codes in APEC member economies can be categorised according to three fundamental approaches (Chong 2013).

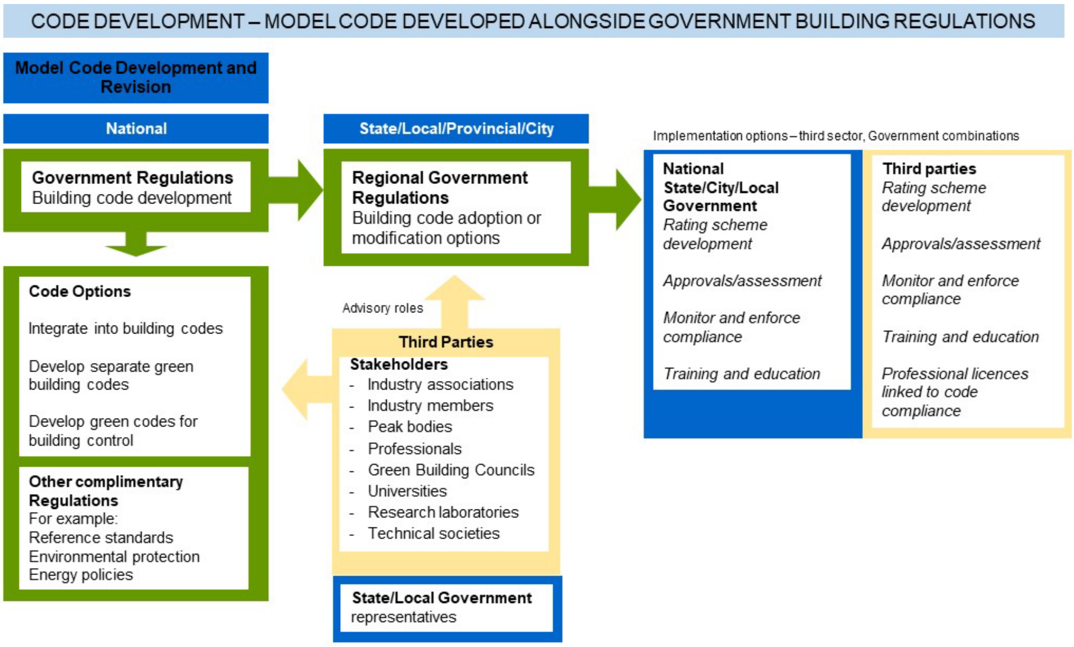
- **Industry-led model codes** developed separate from building regulations: in this approach energy and often other environmental performance requirements are typically proposed and incorporated into model codes by multiple industry stakeholders in hearings or workshops. These codes are then initially adopted by governments as voluntary performance requirements, trialled on demonstration projects, and can then become mandatory requirements (Diagram 2).

Diagram 2: Industry-led model code development



- **Government-led model codes** developed alongside building regulations: In this case government bodies lead the development of energy performance provisions of a building code by convening industry stakeholders to debate the scope and performance levels under consideration, and possible implementation pathways including which provisions should be mandatory, and which should be voluntary. Government can also establish agreed revision cycles and long-term performance targets (Diagram 3). This approach is implemented in all participating APEC economies.

Diagram 3: Government-led model code development

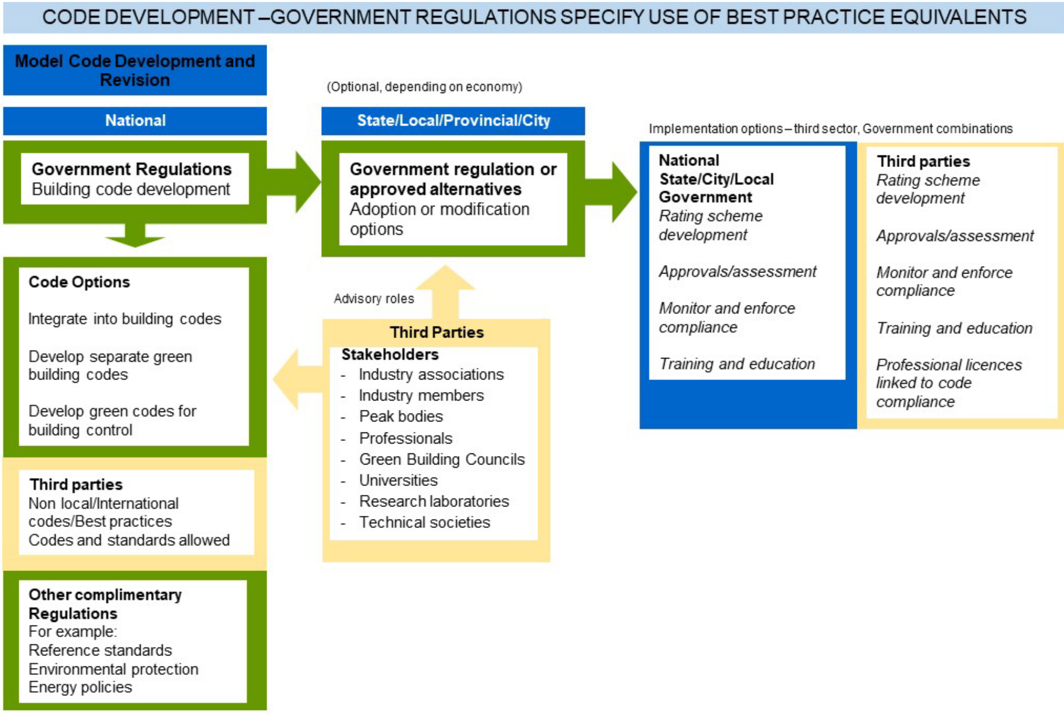


- **Model code development using equivalent standards and best practices from international and industry codes**: Governments may also develop a model code by adapting existing international standards and codes to their local circumstances (Diagram 4).

To be successful and adhere to international best practices all of these approaches require:

- Effective stakeholder engagement and capacity building to ensure energy performance provisions of codes are understood and accepted by the building industry;
- Good governance of code implementation between national, regional and local governments to ensure coordination of code development, adoption and enforcement, and
- Robust enforcement and compliance systems, such as plan reviews, site inspections, and mandatory certification and disclosure of energy performance.

Diagram 4: Model code development using industry and international standards



Stakeholder Engagement & Capacity Building

All participating economies have developed approaches to engaging industry stakeholders in code development, and alignment with voluntary programs including green building rating schemes. National Green Building Councils are becoming more prevalent in overall building energy policy development, and are influential in Government decisions to adopt green building standards as either aligned voluntary schemes for promoting buildings that exceed minimum performance requirements, or, as a proxy for a national energy performance requirement in a building code.

Compliance training for building professionals and officials is also common among participating economies. However, compliance training programs for students have only been reported by Australia, China and Singapore.

Good Governance

In terms of governance, it is common for building energy codes to be developed by national governments, adopted and adapted to regional climate and market conditions by state or sub-national authorities, and then enforced by local governments. This is the case for all participating APEC economies, with the exception of China which gives responsibility for each of these roles to national, provincial and local branches of MOHURD.

Many APEC economies include voluntary implementation pathways for additional measures within their codes, or support voluntary rating schemes that include comprehensive measures. This is an important step towards implementing more comprehensive energy uses and functions in mandatory building codes.

Voluntary processes are used by many economies to introduce new requirements to industry professionals, to include residential buildings, and as a pathway towards more stringent mandatory codes. However, implementation of codes, including using rating schemes, requires adequate training of industry professionals in applying code requirements or using rating tools, and ensuring that code enforcers, either government or industry, have the expertise to check compliance. There is scope for mentoring from economies with more developed implementation systems.

Enforcement & Compliance
A best-practice approach to enforcement and compliance would involve checking a building for compliance during design, construction, pre-occupancy and then through a post-occupancy audit of actual energy consumption. However, this is not the common approach among APEC economies overall, nor among the eight economies participating in this study.

Five participating economies (Australia; China; Indonesia; The Philippines; and Singapore) report compliance checking through to the pre-occupancy stage. Australia and Singapore require post-occupancy energy auditing for commercial office buildings. Thailand reports checking compliance at design and during construction, while Viet Nam currently requires compliance checking of building design only. Only half of the participating economies report using penalties for non-compliance. Effective enforcement of, and compliance with building energy codes therefore continues to be a major issue among all participating economies, and reinforces the issue of compliance as a common global issue of concern (IPEEC, 2015).

3.2.4 Technical requirements

The technical requirements of a building code are the performance standards applicable to the building as a whole, the building envelope (floors, facades and roofs), building materials and components, technical systems such as water heating, lighting and HVAC, and requirements for incorporating renewable energy (GBPN 2013). Comprehensive technical requirements in an energy code regulate more of a buildings energy performance, but add complexity to code implementation. The scope of technical requirements included in a code must therefore balance capturing key influences on energy demand, with the capability of the local industry to comply, and jurisdictions to enforce. The scope of technical requirements therefore varies in different code regimes (Table 3).

Table 3: Comparisons of energy uses and functions covered by technical requirements in model codes and selected best-practice economies

	Thermal characteristics (shell and internal partitions etc)	Air-tightness	Heating installation	Air-conditioning installation	Indoor climate conditions	Dehumidification	Ventilation	Natural ventilation	Hot water supply	Technical installations	Lighting	Daylight	Position and orientation, outdoor climate	Passive solar systems and solar protection	Heat recovery	Renewable energy
EU Energy Performance in Buildings Directive	●	●	●	●	●		●	●	●		●		●	●		
ASHRAE 90.1	●		●	●			●				●					
IECC	●		●	●			●				●					
US New York	●	●	●	●			●		●	●	●	●			●	*
Singapore	●	●		●		●	●	●	●	●	●	●	●	●	●	*
Ireland	●	●	●	●			●	●	●	●	●	●	●	●	●	●

Sources: IEA 2008, GBPN 2013. Note: * = options for renewable energy.

Minimum technical requirements need to cover the major building components and technical systems that most significantly influence energy use in different building types for particular climate zones. In general, this means including performance requirements for the building envelope, heating, cooling, lighting and hot water systems. Minimum requirements usually set standards for the building envelope including allowable heat loss (U-value), solar heat gain through windows and window to wall ratios. Increasingly air tightness, building orientation, shading, light and HVAC equipment is also included (IPEEC 2015a).

All participating APEC economies include technical requirements for the building envelope, HVAC and lighting. Overall building energy efficiency requirements are mandated in Australia, Indonesia, Singapore and Viet Nam, and are voluntary in Malaysia. Inclusion of technical requirements for hot water, mechanical systems, the site or urban context, renewable energy and maintenance are less consistent across participating economies.

3.2.5 Overall performance

The overall energy performance of the building stock needs to be monitored over time in order to determine whether a building energy code is succeeding in reducing building energy demand, and is contributing to achieving energy savings and greenhouse gas emission reduction goals. In order to effectively monitor the overall performance of building energy codes on energy savings and climate change mitigation, it is best-practice to collect good quality data on the following criteria (GBPN, 2013):

- Floor Area (m2);
- Number of buildings by building type and age;
- Occupancy by building type;
- Overall energy use;
- Heating, Cooling, Hot Water, Lighting and Appliance Energy consumption;

- Fuel mix and GHG emissions factors;
- Rate of New Construction;
- Rate of Renovation;
- New Building Energy Use;
- Ownership (Public or Private);
- Tenure (Owner occupied or rental).

This data can be used to calculate baseline energy demand from the building stock, and to generate future scenarios. It is important for communicating the energy savings and climate mitigation potential of different policy options, and for analysing the gap between business as usual projections and pathways toward energy savings and climate mitigation goals. Tools such as the Common Carbon Metric provide an internationally recognised approach to conducting such analyses[2]. Energy efficiency and climate change mitigation are not always considered top priorities for policy makers. It is therefore advisable to collect data on the co-benefits of energy efficient buildings such as employment, improved health and productivity in order to support arguments for further development of building energy codes.

As logical as this may seem, the regular, systematic collection and monitoring of post-occupancy energy use data is not yet common practice globally (GBPN, 2013). Among participating APEC economies, Singapore, Australia, Indonesia, Malaysia and Viet Name report energy auditing programs for commercial buildings in place. However, data availability and quality are common challenges in most other jurisdictions, as are limitations in cost-effective data-collection methodologies.

3.3 Common Challenges

This analysis reveals common issues for improving the development and implementation of building energy codes in the following areas.

Code design and governance
Most APEC economies have energy performance requirements either incorporated into building codes, or as separate codes or laws. The use of voluntary rating programs is also widespread. Commercial buildings are covered by mandatory energy performance requirements in 14 APEC economies and by voluntary requirements in 4 economies. Energy performance requirements are mandatory for residential buildings in 9 economies and voluntary in 10 economies. Expanding energy performance requirements to residential buildings and building renovations is not yet common and needs to be supported.

Scheduling regular revisions of energy performance requirements is not common. This hinders capacity building for, and investment in, very low-energy buildings.

Structural coverage of codes
Requirements for residential buildings are less advanced in most participating APEC economies. Technical requirements need to be further developed to suit locally available building materials, technology and construction methods. Collaboration opportunities include

[2] The Common Carbon Metric is an online tool for calculating the energy and energy-related ghg intensity of building stock. It offers top-down, bottom-up and hybrid calculation approaches: see www.ccmbuildings.net for more information.

developing locally appropriate options, and ways to adapt existing international technical specifications to varied building typologies within participating APEC economies.

Almost all participating APEC economies have mandatory technical requirements for basic energy efficiency, HVAC and lighting components. Most economies either include voluntary options, or have voluntary rating schemes, which provide a basis for more comprehensive technical requirements. Internationally, technical requirements are well developed and technical specifications exist for all climatic regions, however they can require highly developed building materials, technology and construction systems.

Implementation and compliance

Compliance checking is very common at design and construction phases of new building projects. However, pre-occupancy and post-occupancy compliance checking is still not common among participating APEC economies. This hampers the monitoring of actual performance and the ability to evaluate the impact of building energy codes on building energy demand and energy savings.

Implementation of codes, including using rating schemes, requires adequate training of industry professionals in applying code requirements or using rating tools, and ensuring that code enforcers, either government or industry, have the expertise to check compliance. Voluntary processes are used by many economies to introduce new requirements to industry professionals as a pathway towards greater mandatory implementation. There is scope for mentoring from economies with more developed implementation systems. Compliance is a significant issue internationally, particularly for pre occupancy and post occupancy evaluations. There is scope for all economies to collaborate on all aspects leading to greater compliance.

Table 4 below summarises the status of energy efficient building codes in each participating APEC economy and highlights areas of success as well as areas for improvement.[3]

Opportunities for collaboration are highlighted using a colour-coded ranking system according to how many economies have developed each aspect required for best practice as follows:

(green)	Comprehensive coverage	Addressed overall, unless more voluntary than mandatory measures are included
(yellow)	Progress towards good coverage	Addressed by most economies, unless more voluntary than mandatory measures are included
(orange)	Significant gaps in coverage	Addressed by less than half of economies
	Procedural processes which are not ranked	

[3] Table 4 is indicative only as it does not show the extent or coverage of a particular item. For example, while the building code includes new commercial buildings in most jurisdictions, their coverage depends upon the GFA specified in the building code and this varies between jurisdictions.

Table 4: Summary of Energy Efficient Building Codes in participating APEC economies

	Australia	China	Indonesia	Malaysia	The Philippines	Singapore	Thailand	Viet Nam
STATUS OF REGULATIONS*:*								
Included in standard building codes/laws	●	●		●		●		
Included as a separate building code/law			●	●	●	●	●	●
Linked to a separate rating system	●	●	●	●	●	●	●	●
Only made mandatory at sub-national level	●		●	●		n.a.		
HOLISTIC APPROACH (● = Mandatory, e = covered with exemptions, o=option)								
New commercial buildings	●	●	e	●	e	●	●	e
Renovation of existing commercial buildings	●		●		●	●		●
New large residential	●	e	e	e	e	●	e	e
Other building types	●		e	●	e	●	e	●
Industrial				●		e	e	
Small/medium residential				e				
Performance approach	o	o				●		
DYNAMIC PROCESS								
Levels beyond minimum	●	●		●		●	●	
Are reviewed regularly **(**S=scheduled, U=unscheduled)	U	S	S	U	U	U	U	U
Zero energy target (P=planned)		P	P			P		
IMPLEMENTATION								
Stakeholder engagement and capacity building								
Programs for professionals	●	●	●	●	●	●		●
Programs for students	●	●	●			●		●
Good governance								
Support for voluntary rating schemes	●	●	●	●	●	●	●	●
Compliance and enforcement								
Buildings are checked for energy efficiency compliance at: (G=by Government agency, T=by Third party)								
Design	G/T	G/T	G	T	G	G/T	G	G
Construction	G/T	G/T	G		G	G/T	G	
Pre occupancy	G/T	G/T	G		G	G/T		G
Post occupancy evaluation		G/T		T		G/T		
Penalties for non-compliance								
Refusal of permission to construct	●	●	●	●		●		●
Refusal of permission to occupy	●	●	●			●		
Fines	●	●				●		
Suspension/ loss of licence	●	●						
Public publication of non-compliance		●						
Incentives								
Tax incentives (C = City government)		●	C		C			
Grants and subsidies	●			●		●		
Industry recognition	●			●		●		
Fast track construction approval								

	Australia	China	Indonesia	Malaysia	The Philippines	Singapore	Thailand	Viet Nam
TECHNICAL REQUIREMENTS (● = Mandatory, v = voluntary)								
Building envelope	●	●	●	●	●	●	●	●
HVAC	●	●	●	●	●	●	●	●
Lighting	●	●	●	●	●	●	●	●
Technical energy efficiency standards	●		●	v		●		●
Hot water	●	●			●	●		●
Maintenance		●				●		
Renewable energy	●	●		v		v		
Mechanical systems	●		●	v		●		●
Site/urban context		●	v	v	v	v		
OVERALL PERFORMANCE (● = Yes, P = partly)								
Data collected to calculate baseline energy demand	P		P	P		●		P

Appendix 1 provides more detail on each these participating economies outlining for each:

- the factors impacting on their building energy efficiency;
- the development, features and implementation of their building energy code, and
- the issues and opportunities.

Table 14 in Appendix 2 expands on Table 4 to provide a summary landscape of building energy codes in all APEC economies.

4. OPPORTUNITIES FOR COLLABORATION

4.1 National priorities for improving building energy performance

In order to determine priorities for collaboration, interviews with policy makers, codes experts and local green building council representatives in participating countries were conducted. The following section summarises the priorities expressed by participating economies. The full list of priorities is presented in Table 5 below.

Australia

Australia has developed energy provisions within its National Construction Code (NCC) which apply to both residential and non-residential buildings. Performance and prescriptive compliance pathways are provided. A mandatory rating and disclosure program called the National Australian Building Energy Rating Scheme (NABERS) applies to large commercial Buildings, but is not directly connected to the NCC requirements. The national voluntary green building rating scheme 'Green Star' complements regulatory measures by providing recognition to buildings that aim to perform beyond minimum requirements.

Despite this progress, recent studies indicate that the effectiveness of these policies is being undermined by poor engagement and compliance by the construction industry (Pitt & Sherry, 2014). Measures also need to be put in place to encourage residential energy renovations, and to stimulate demand for very low or net zero energy buildings. To this end, a National Energy Productivity Plan has been adopted, under which measures to improve code compliance, increase energy performance requirements for new buildings, and introduce mandatory energy rating and labelling for residential buildings are being considered (COAG Energy Council 2015).

The following priority areas for collaboration identified by interviewees in this project reflect the need to address such issues:

- Building capacity through education and training for local governments to enforce compliance;
- Extending post-occupancy performance certificates to include residential buildings, and
- Monitoring and evaluating the impact of energy provisions of the NCC including determining the most cost-effective impacts of national measures.

China

China has a well-developed system for developing and implementing building energy codes. China's building energy codes cover public, commercial and residential buildings in most of its climatic zones. Its enforcement system is rigorous with detailed requirements and penalties for non-compliance, particularly in large and medium-sized cities. The capacity and infrastructure for enforcement in smaller towns and rural areas is limited and made more complex by the large number of single-family homes being built. Building products are subject to testing and the building energy code provides manufacturers with incentives to have their products tested and rated.

Yet, as the largest new construction market in the world (Evans et al. 2010), China faces some major challenges. Under its Nationally Determined Contribution (NDC), it seeks to lower carbon dioxide emissions per unit of GDP by 40% to 45% from the 2005 level. Achieving the energy savings potential of the building sector is key to meeting these commitments. The following priority areas reflect the need for China to address the above issues:

- Building capacity through education and training particularly in smaller towns and rural areas;
- Developing building products that not only meet energy efficiency goals but also fire and safety goals, and
- Finding ways in which to minimize the cost of implementing energy efficiency building codes.

Indonesia

By 2020 Indonesia has made commitments to reduce national GHG emissions by up to 26% with domestic capacity and up to 41% with international support. Improving the energy efficiency of the building sector is fundamental to achieving these goals. The energy savings potential of Indonesia's building sector is estimated to be between 25% and 30% compared to business as usual. Reducing demand for, and improving the efficiency of residential air-conditioning represents 66% of this savings potential (MoE, 2014).

In this context, Indonesia's system of building efficiency standards covering lighting, air-conditioning, building envelope and energy auditing for commercial buildings offers appropriate technical requirements, and the opportunity to expand the scope of application to residential buildings. This opportunity is reflected in the priorities for collaboration expressed by the interviewee from Indonesia, namely:

- Extending the structural coverage of their Codes so that they cover (i) not only new buildings but renovations to existing buildings and (ii) new residential buildings less than $500m^2$ GFA and new commercial buildings with less complexity and with less than $5{,}000m^2$ GFA;
- Developing a roadmap for future changes in Codes, and
- Work with local government and other stakeholders to develop the capacity to enforce compliance with Codes more widely.

Already, some jurisdictions within Indonesia, such as Jakarta province and Bandung, have developed and adopted the more stringent standards of a mandatory green building code. The national government is also in the process of developing a green building toolkit to assist local governments implement mandatory green building codes.

Malaysia

Malaysian commercial and residential building sectors account for about 13% of national annual energy demand and about 48% of final electricity demand which is growing at about 6% per year. Electricity production contributes to 43% of Malaysia's total annual greenhouse gas (GHG) emissions. The residential sector is responsible for more than 80% of this electricity demand. Energy efficiency in the building sector, particularly targeting reduction in the growth of electricity demand in residential buildings therefore has significant energy savings and GHG mitigation potential (UNDP, 2011).

Malaysia has implemented mandatory energy performance requirements for commercial buildings, and the voluntary Green Building Index which extends the scope of environmental performance considerations and building types that can be covered by standards. As in many APEC economies, responsibility for adopting mandatory codes rests with sub-national (state) governments, while local government is responsible for code implementation and enforcement. This creates governance and compliance challenges that require long-term planning, stakeholder engagement and capacity building to overcome. These issues are recognised in the priorities for collaboration expressed by Malaysian representatives in this project:

- The development of a mandatory code which applies to both new and existing residential and commercial buildings and its adoption by the States;
- Complementary incentives in support of the Green Building Index for the construction of buildings which exceed a mandatory energy efficient building code;
- Develop a strategy for the implementation of a mandatory code including training, building capacity and enforce compliance;
- Develop a roadmap for future changes in Code, and
- Work with state governments, local governments and other stakeholders to develop the capacity to enforce compliance with Codes more widely.

The Philippines

The Philippines has introduced its first national green building code in 2015. The code is broad in scope and includes provisions for the building envelope, natural ventilation, building envelope colour, roof insulation, efficiency of mechanical and electrical systems, water efficiency, material sustainability, solid waste management, site sustainability and indoor environmental quality. On the other hand, it has its limitations. While it covers all new construction, the GFA thresholds for additions, alterations, conversions and renovations are relatively high, therefore not yet applying to the large stock of smaller building.

The green building code is enforced through regional, city and local governments. Some of the larger cities have used the code as a framework to develop their own green building ordinances and have established green building units to enforce them. In addition, the green building code is supported by the use of voluntary standards and guidelines in various rating tools. However, for the most part, local governments have yet to develop the technical and human resources to enforce the code.

The following priority areas reflect the need for the Philippines to address the above issues:

- Building technical and human resource capacity through education and training;
- Extending the scope of the green building codes, particularly for additions, alterations, conversions and renovations;
- Providing a roadmap so that industry can transition into future requirements, and
- Making the disclosure of building energy use mandatory to facilitate competition among building owners for tenants.

Singapore
Singapore has rapidly advanced its package of building energy performance policies and is recognised as a best-practice jurisdiction with regards to building energy code implementation (GBPN, 2013). Mandatory performance regulations are well aligned with the voluntary Green Mark rating program that provides a framework for achieving beyond minimum performance requirements, and offering financial performance incentives the Singapore Green Mark rating scheme is guided by a long-term plan for achieving significant energy savings and reducing the environmental footprint of the building sector.

Implementation of these policy measures is enhanced by extensive training and capacity building programs offered by the Building and Construction Authority of Singapore. Singapore is now looking toward increasing the performance requirements for certain building types and improving industry awareness of the code requirements and opportunities facilitated by its building policy packages. As with many other countries, there is room for improvement in compliance with code requirements. In this context, Singapore priorities for collaboration are focussed on:

- Identifying commercially viable technologies and practices that have the potential to achieve significant improvement in building energy efficiency;
- Expanding the scope of energy rating and disclosure policies;
- Ensure that the requirements of the Codes are well accepted and complied with, and
- Learning by monitoring progress and establishing a data-base of best-practices.

Thailand
Thailand has adopted a National Energy Efficiency Development plan which aims to reduce energy intensity per unit of GDP by 25% by 2030. Key to achieving this goal is realising the estimated ghg mitigation potential of 14Mt available through improved energy efficiency and incorporation of renewable energy in the commercial and residential buildings sectors (KMUTT 2014).

The suite of building energy policies being developed and implemented in Thailand include energy efficiency measures for new commercial and public buildings and retrofitting projects over 2,000m^2. This has the potential to influence the performance of a large range of the urban building stock. As with other countries that require adoption of codes by states and implementation by local authorities, compliance is a key issue. There is a need to improve compliance through awareness raising and capacity building in state and local governments, as well as with industry stakeholders. Lack of compliance undermines the ability of the national government to establish ambitious long-term policy goals. These needs are reflected in the priorities for collaboration offered to this project:

- A strategy to implement the code;
- Man-power to implement the code and enforce compliance;
- Training of developers, government departments and state enterprises, local government inspectors in the Code;
- The cost of implementing the provisions of the Code, and
- Co-ordination between different Ministries.

Viet Nam
A third version of the Vietnamese Energy Efficiency Building Code (VEEBC) will be released in 2017. The code has limited structural coverage and applies to commercial, public and residential buildings over 2,500m^2.

VEEBC is supported by the use of voluntary standards and guidelines in various rating tools. Some city governments, such as Da Nang, have pro-actively prioritized building energy efficiency. For the most part, education and training on VEEBC is under-resourced and patchy and reliant on international support and finance. Local governments who have primary responsibility for adopting the national code and enforcing it, have yet to develop the technical and human resources to enforce the code.

The following priority areas reflect the need for Viet Nam to address the above issues:

- Build capacity among private developers and local government officials through education and training, including building knowledge of the Code and implications; building expertise and skills in assessing plans and conducting site inspections during and after construction;
- Enforce compliance with the Code by building the capacity of local governments
- Further develop VEEBC, in particular its structural coverage and inclusions, and
- Develop an implementation strategy and signal longer term changes to the Code so that private developers and producers of building materials can prepare for them.

Table 5 below outlines the priorities the priorities for each participating APEC economy as nominated by interviewees.

Table 5: Priorities nominated as high by interviewees of each participating APEC economy

	Australia	China	Indonesia	Malaysia	The Philippines	Singapore	Thailand	Viet Nam
Code development								
Develop building codes/standards/regulations		●	●		●			●
Extend the structural coverage of the building code			●					
Extend the measures coverage of the building code								
Introduce a mandatory process for code compliance		●	●	●				
Introduce a performance approach		●						
Signal long term targets and goals		●	●	●	●		●	●
Engage better with stakeholders				●			●	
Introduce a regular review of the building code		●						
Supportive infrastructure								
Build capacity through training and education	●	●	●	●	●	●	●	●
Develop software tools for assessment		●				●		
Develop a buildings database as examples of best practice			●			●		
Compliance checking								
Require design review (plans)		●	●					
Require site inspections during construction		●						
Require pre-occupancy checks			●					
Require post-occupancy checks	●		●					
Penalties and incentives								
Introduce penalties for non-compliance			●					
Introduce incentives – financial and trade-offs								
Data collection and evaluation								
Collect compliance data		●	●					
Evaluate performance against the building code	●							
Building materials and energy performance certificates								
Make laboratory facilities available								
Introduce/expand building rating, labelling, and disclosure		●	●	●	●	●		
Introduce/expand building component standards and labels		●						
Introduce/expand appliance standards and labels		●						
Other								
Technology development and exchange			●			●		
Pilot Projects								●

4.2 Summary: Scope of Collaboration for a Potential Asia-Pacific Building Codes Forum

The outcomes of this research demonstrate that despite the varying stages of development of building energy codes and supporting policies among participating APEC economies, there are a range of common issues and priorities for collaboration that could be addressed through regional knowledge-exchange and collaboration, which could be supported by an ongoing Asia-Pacific Building Codes Forum.

It is clear from the preceding analysis that economies need more support to address significant gaps in code design and coverage. Referring to the issues presented in Table 4 above the following common challenges are those that are being addressed by less than half of the participating economies or which are being addressed but not yet at best-practice level.

- Developing strategies for regular code upgrading including regular schedules for code reviews and increasing energy performance requirements towards very low, net zero or positive energy buildings.
- Extending the structural coverage codes to more comprehensively encompass residential building energy performance, and renovation projects
- Post occupancy evaluation or auditing of operational building energy performance and integration of this into rating and disclosure policies
- Enforcement of and compliance with building energy code requirements, including the use of incentives and penalties.

In terms of frequency of response, respondents from economies prioritised the following issues (in rank order):

1. Support for setting long term policy goals and performance targets;
2. Training and capacity building in code design, implementation, compliance and stakeholder engagement;
3. Support for developing or extending building energy codes and standards;
4. Support for developing or expanding energy performance rating, labelling and disclosure
5. Support for introducing mandatory codes, improving stakeholder engagement and collecting compliance data.

The priorities for collaboration identified in this study reinforce the findings of previous studies into priorities for international collaboration on building energy policies and codes. What emerges is a confirmation that exchange of best practices between peers, training and capacity building are sought-after by building energy policy makers. While there are a number of platforms available to, or being participated in, by APEC economies, there is no dedicated platform or forum specifically on building energy codes in the Asia-Pacific region.

4.3 Next Steps

This discussion paper has presented the status of building energy codes in APEC generally, and has investigated more closely priority issues and potential opportunities for collaboration between eight participating APEC economies. This has been done to support discussion at a strategic workshop on the Asia-Pacific Building Codes Forum to be held in Singapore on 7th July 2017. This workshop will further refine the priorities identified in this research and provide ideas to facilitate regional collaboration going forward, including the potential set up a regional building codes forum to support the rapid development and effective implementation of ambitious building energy codes.

The workshop will aim at facilitating discussions on:

- The findings of this study, with a view to confirming or refining the key findings;
- Common challenges and opportunities for collaboration, with a view to prioritising potential future actions;
- The potential for and interest in the establishment of an Asia-Pacific building codes forum, including:
    - Goals;
    - Ownership and leadership;
    - Immediate next steps;
    - Potential future agenda, based on potential areas for knowledge-exchange outlined in this discussion paper.

Outputs from this workshop will be summarised into an outcomes report to be presented to the APEC Incubator stakeholder forum to be held on August 8th in Jakarta.

Appendix 1: Status of Building Energy Codes in Participating APEC Economies

Introduction

Eight APEC economies were selected for more in-depth analysis: Australia; China; Indonesia; Malaysia; The Philippines; Singapore; Thailand; and Viet Nam.

This section briefly outlines for each of these participating APEC economies:

- the factors impacting on their building energy efficiency;
- the development, features and implementation of the Building Energy Code, and
- the issues and opportunities.

Australia

The factors impacting on building energy efficiency are outlined in Table 6 below.

Table 6: Australia: factors impacting on building energy efficiency

Population		
	Population (millions)	23.8
	Population density (persons per km^2)	3
Level and pace of urbanisation		
	1960	82%
	2015	89%
	% increase	9%
GDP and growth in household income		
	Purchasing power parity gross national income	$45,320
	Gross domestic product per capita % growth	0.8%
Energy supply – sources and growth in demand		
	Access to electricity: % of population	100.0%
	% renewable energy consumption	9.5%
	CO^2 emissions: per capita metric tons 2013	16.3

Climate zones[#]	Urban areas are predominantly: Humid subtropical, Oceanic and Mediterranean Other areas: Tropical savannah, Semi-arid and Desert	
Sub-national/ private sector commitments	Total Commitments: Emissions reduction - 118 Private finance – 105 Renewable energy - 57 Building – 50 Energy access & efficiency – 44 Use of carbon price – 37	Resilience – 17 Forest – 11 Transport – 6 Short term pollutants – 5 Other - 9
	Governments (2): Australian Capital Territory and South Australia Companies (3): Albright & Wilson (Australia) Ltd, Australia Post, Caltex Australia Investors (8): Australia and New Zealand Banking Group, Australian Ethical Investment, Australian Ethical Superannuation, AustralianSuper Bank Australia, Commonwealth Bank of Australia, Insurance Australia Group, National Australia Bank (NAB) Cities (13): Adelaide, Byron Shire, Canberra, Hobart, Joondalup, Mandurah, Melbourne, Moreland, Mornington Peninsula Shire, Penrith, Perth, Port Phillip, Sydney	

Energy policy packages	Australia’s NDC is to implement an economy-wide target to reduce greenhouse gas emissions by 26 to 28 per cent below 2005 levels by 2030

Climate zones for each APEC economy are based on the Koeppen-Geiger classification as reported in Weather online except for China
Sources: The World Bank 2017; Global Climate Action 2017; Weather online 2017; UNFCCC 2017

In Australia, the energy efficient building code is included in the National Construction Code (NCC) developed by the Australian Building Codes Board. ABCB is a standards writing body with representatives from Commonwealth, State/Territory and local governments as well as industry. The NCC includes provisions for building envelope, HVAC, lighting, service water heating, maintenance, thermal comfort and building energy audit. The current approach of the NCC is prescriptive with some performance-based elements. It is moving towards a performance-based approach. Through separate regulations (the Commercial Buildings Disclosure Program), post occupancy energy performance certificates are required at point of sale or lease for commercial buildings.

ABCB supplies training modules and resource kits for training institutions to provide consistent information about the NCC. They also provide online resources (video and written).

It is the State/Territory governments that adopt and adapt the NCC to fit their conditions. It is at this level of government that the NCC becomes mandatory. The State/Territory governments enforce compliance through local governments.

Supportive infrastructure includes:

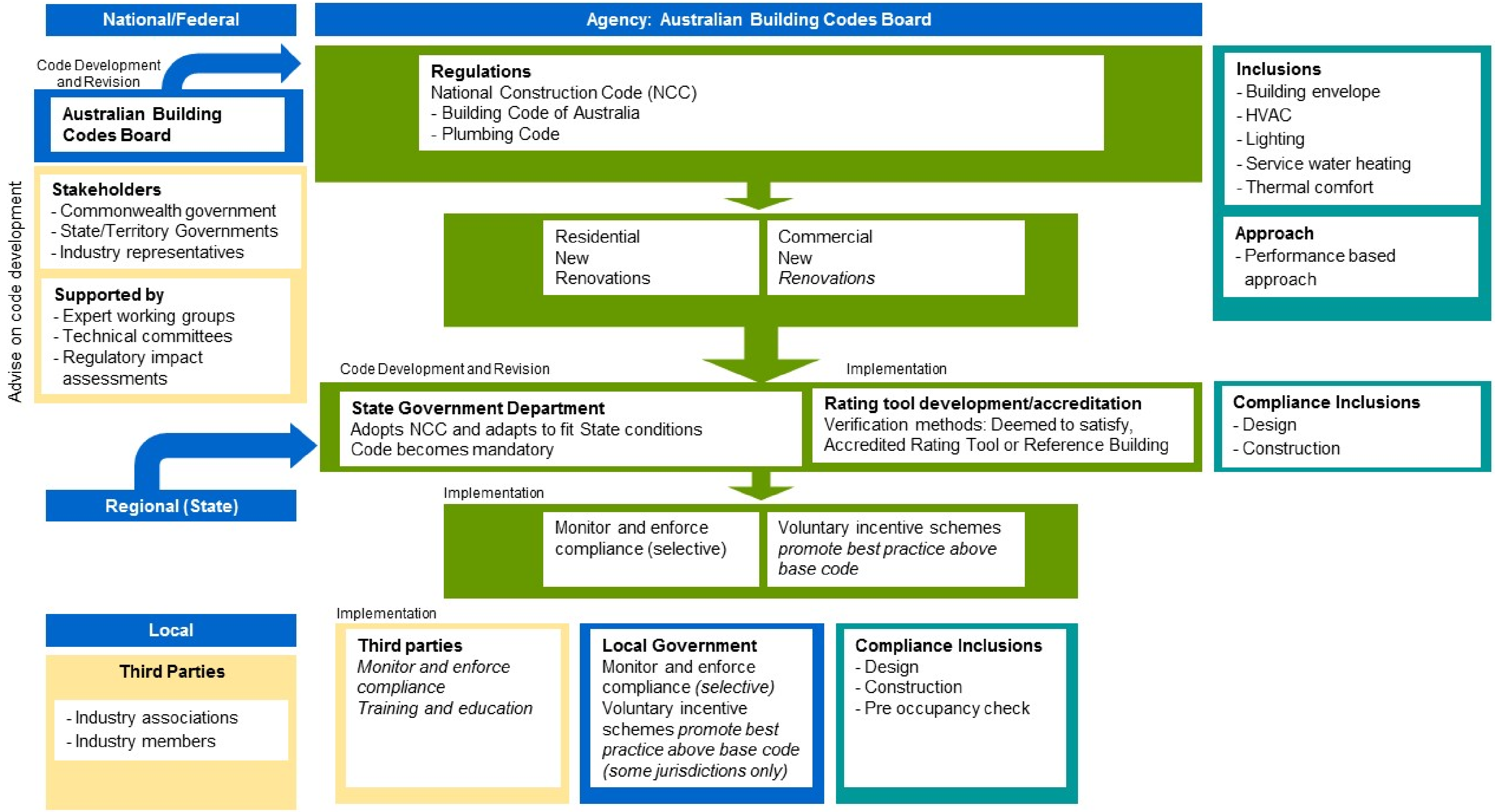
- for commercial buildings, the National Australian Built Environment Rating System (NABERS) has Energy Commitment Agreements for developers and owners and provides building performance measures post certification;
- for residential buildings, the Nationwide House Energy Rating Scheme (NatHERS) Software Accreditation Protocol is used accredit assessment tools for dwellings.

Diagram 5 below outlines the governance and regulatory structure for code development in Australia.

Issues and opportunities
The issues for Australia are:

- Developing the capability at local government to enforce compliance;
- Extending post-occupancy performance certificates to include residential buildings;
- Working out the most cost-effective impact of national measures.

Diagram 5: Australia: Governance and Regulatory Structure for Code Development



Sources: originally based on IPEEC 2015b and, revised/updated through interviews

China

The factors impacting on building energy efficiency are outlined in Table 7 below.

Table 7: China: factors impacting on building energy efficiency

Population		
	Population (millions)	1,371.2
	Population density (persons per km^2)	146
Level and pace of urbanisation		
	1960	16%
	2015	56%
	% increase	250%
GDP and growth in household income		
	Purchasing power parity gross national income	$14,320
	Gross domestic product per capita % growth	6.4%
Energy supply – sources and growth in demand		
	Access to electricity: % of population	100.0%
	% renewable energy consumption	17.1%
	CO^2 emissions: per capita metric tons 2013	7.6

Climate zones	Severe Cold and Cold Zone, Hot Summer and Cold Winter Zone, Hot Summer and Warm Winter Zone, Subtropical Zone, Tropical Zone
Sub-national/ private sector commitments	Total commitments: Emissions reduction - 62; Building - 13 Use of carbon price - 54; Resilience - 6 Energy access & efficiency - 44; Innovation - 5 Private finance - 17; Agriculture - 1 Renewable energy - 14; Forest - 1 Transport - 14; Other - 3 Companies (15): Aluminum Corporation of China, China Energy Conservation and Environmental Protection Group Co., Ltd., China Minmetals Corporation, China Mobile, China National Offshore Oil Corp. (CNOOC), China Ocean Shipping Group (COSCO), China Petroleum and Chemical Corporation (Sinopec), China Railway Corporation (CR), China Resources Cement Holding Limited, China Rilin Industrial Group Co. Ltd., China Shipping Container Lines, China State Construction International Holdings Ltd, CHINACOMM, Hurrytop China Network Logistics, State Grid Corporation of China Investors (3): Agricultural Bank of China, Bank of China, China Industrial Bank Civil Society Organisations (1): China Academy of Railway Sciences (CARS) Cities (3): Anshan, Jinan, Shenzhen
Energy policy packages	China's NDC is that by 2020 it will lower carbon dioxide emissions per unit of GDP by 40% to 45% from the 2005 level, increase the share of non-fossil fuels in primary energy consumption to about 15% and increase the forested area by 40 million hectares and the forest stock volume by 1.3 billion cubic meters compared to the 2005 levels.

Sources: The World Bank 2017; Global Climate Action 2017; UNFCCC 2017

China issued its first building energy code in 1986. This was a design standard for energy efficient heated residential buildings and covered the severe cold and cold zones in the north.

Since that time, China has progressively revised the design standard for this Severe Cold and Cold Zone and issued design standards for energy efficient residential buildings in another two of its five climate zones: Hot Summer and Cold Winter Zone and Hot Summer and Warm Winter Zone.

The current regulations on Building Energy Efficiency are spread across a number of design standards, codes of acceptance and technical standards – see Diagram 6.

These regulations are mandatory for new and renovated public and commercial buildings, new and renovated urban residential buildings and are voluntary for rural residential buildings.

The Ministry of Housing and Urban-Rural Development (MOHURD) is the agency responsible for the regulations governing energy efficient building codes. MOHURD also play a role in training and education. When a new code issued, MOHURD conduct training tours.

Within MOHURD, the China Academy of Building Research (CABR) and the Center of Science and Technology and Industrialization Development (CSTID) are important stakeholders involved in the development and evaluation of the regulations. Other stakeholders that have played a role in the design of standards are universities, local research institutions and companies.

Within the regulatory framework established by MOHURD, provincial/city governments also play a role in local code development. Local branches of MOHURD are responsible for local compliance and enforcement. They issue permits for construction and occupancy and, when new codes are being introduced, conduct training.

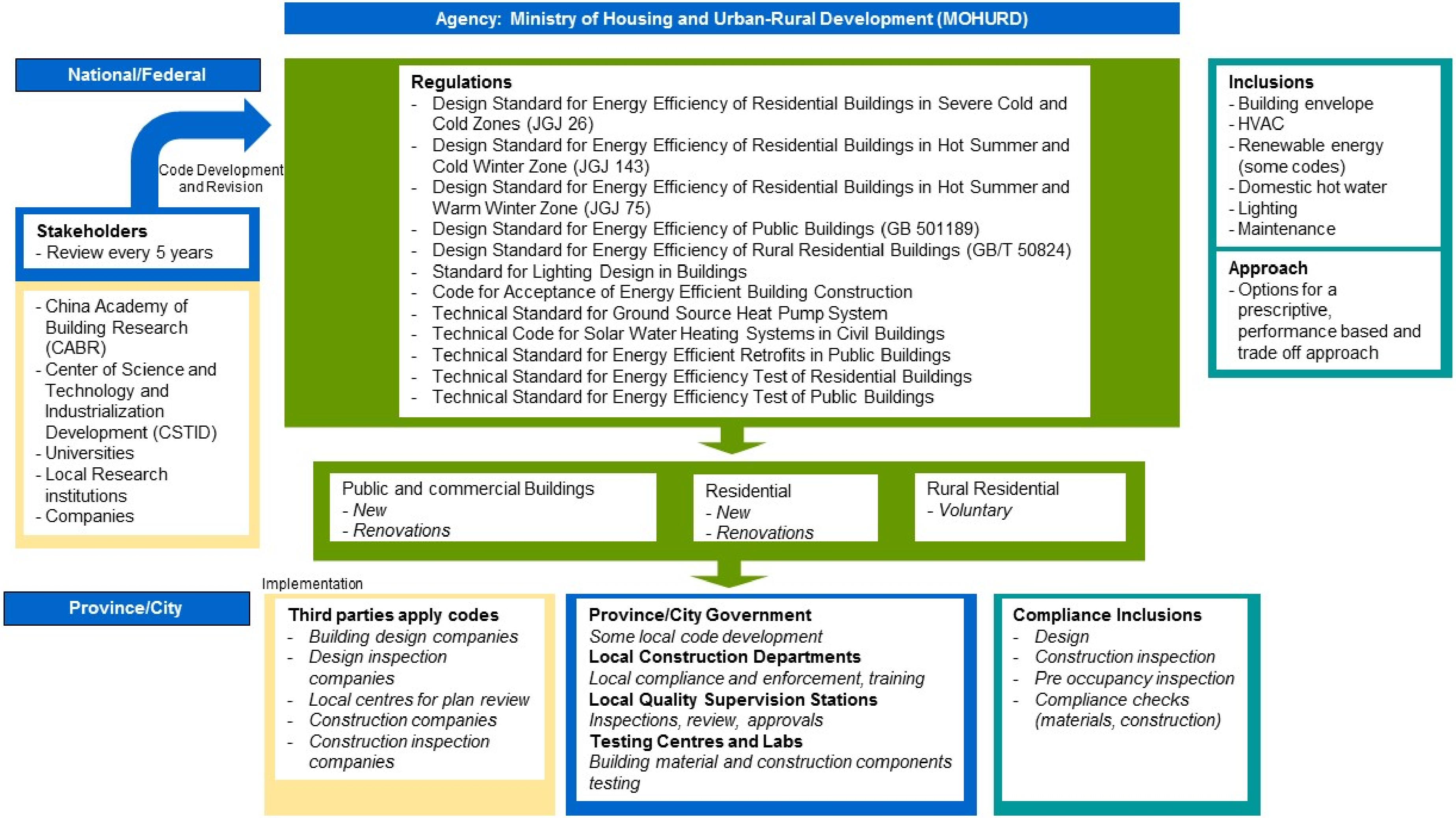
Diagram 6 below outlines the governance and regulatory structure for code development in China.

Issues and opportunities

The issues for China are:

- Post construction evaluation for both mandatory and voluntary certification is weak with a large gap between design compliance and post-construction compliance
- The tensions between the goals of energy efficiency and that of fire and safety, and
- The cost of implementing energy efficiency building codes.

Diagram 6: China: Governance and Regulatory Structure for Code Development



Sources: originally based on IPEEC 2015c and, revised/updated through interviews

Indonesia

The factors impacting on building energy efficiency are outlined in Table 8 below.

Table 8: Indonesia: factors impacting on building energy efficiency

Population		
	Population (millions)	257.6
	Population density (persons per km^2)	142
Level and pace of urbanisation		
	1960	15%
	2015	54%
	% increase	260%
GDP and growth in household income		
	Purchasing power parity gross national income	$10,690
	Gross domestic product per capita % growth	3.5%
Energy supply – sources and growth in demand		
	Access to electricity: % of population	97.0%
	% renewable energy consumption	38.1%
	CO^2 emissions: per capita metric tons 2013	1.9

Climate zone	Tropical rainforest	
Sub-national/ private sector commitments	Total commitments: Emissions reduction - 32 Resilience - 18 Forest - 7 Transport - 2	Use of carbon price - 1 Short term pollutants - 1 Energy access & efficiency - 1 Renewable energy - 1
	Companies (1): Pt. Kereta API / Indonesian Railways (KAI)	
	Cities (20): Balikpapan, Banda Aceh, Bandung, Banjarmasin, Bogor, Bontang, Cimahi, Jakarta, Jambi, Kendari, Kupang, Malang, Mataram, Padang, Probolinngo, Semarang, Sukabumi, Surabaya, Tanjungpinang, Tarakan	
Energy policy packages	In its National Energy Policy (2014) Indonesia's energy conservation goals are to achieve energy elasticity of less than 1 by 2025 and decrease energy intensity by an average of 1% per year to 2025	

Sources: The World Bank 2017; Global Climate Action 2017; Weather online 2017; APEC 2016

In Indonesia, there are more than 40 national standards developed by Standards National Indonesia that relate to building energy efficiency. Among others are: SNI 03-6759-2002 Design of energy conservation in buildings; SNI 03-6389-2011 Energy conservation on the building envelope; SNI 03-6390-2011 Energy Conservation on air-conditioning systems in buildings; SNI 03-6197-2011 Energy Conservation on lighting systems in building structures; and, SNI 03-6196-2011 Energy Conservation on the energy auditing procedure for buildings. These reference standards only become mandatory when they are incorporated into a mandatory national or provincial Building Code.

Given the political structure of Indonesia, the national government is unable to mandate national energy building codes. So, the government encourages and facilitates initiatives by stakeholders. For example, the State Minister of Environment by issuing Regulation 8/2010 on the criteria and certification of environmentally friendly building is said to have the triggered the "Green Building" movement.

In 2012, Jakarta province developed and adopted a green building code. This code became mandatory in 2013. Drawing on this code, the Indonesian Ministry of Public Works and Housing (the Ministry with responsibility for building construction) developed national guidelines on green buildings and issued Ministerial Regulation 02/2015, the National Green Building Guidelines. These guidelines provided a framework for large cities in Indonesia to develop their own mandatory green building codes. For example, using these national guidelines, Bandung adopted its green building code in 2016. This building code went beyond the scope and technical specifications outlined in the national guidelines on green buildings. Jakarta and Bandung are among the leading provinces in developing mandatory green building codes.

In addition to the Ministry of Public Works and Housing, other Ministries with responsibility for green building include the Ministry of Environment and Forestry and the Ministry of Energy and Mineral Resources.

The Green Building Council of Indonesia (GBCI) has developed a rating tool, Greenship. GBCI also offers EDGE certification.

A range of agencies, such as Universities and the Indonesian Association of Architects, provide training and capacity building. The International Finance Corporation (IFC) works with government officials and the private sector to develop their understanding of green building code requirements. In addition, IFC provides knowledge sharing to financial institutions on green building financing opportunities and also to academics on green building trends and requirements to help them in developing a green building curriculum.

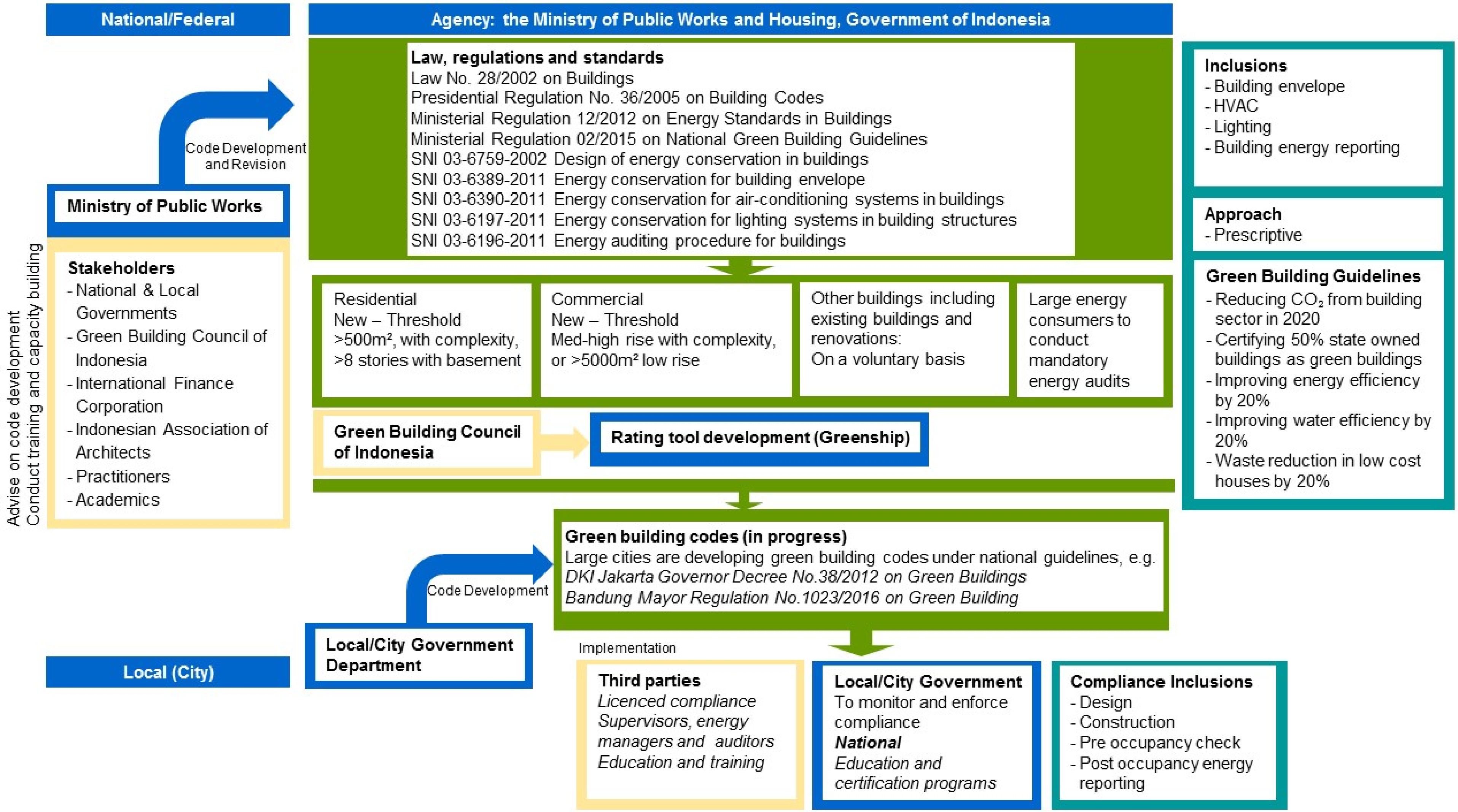
Diagram 7 below outlines the governance and regulatory structure for code development in Indonesia.

Issues and opportunities

Among the issues for Indonesia are:

- The national government is in the process of developing a national green building toolkit so that local government can adopt and implement the national green building guidelines as a mandatory code for their jurisdiction
- Extending the structural coverage of provincial Codes so that they cover (i) not only new buildings but renovations to existing buildings and (ii) new residential buildings less than 500m^2 GFA and new commercial buildings with less complexity and with less than 5,000m^2 GFA
- Develop a roadmap for future changes in Codes
- Work with local government and other stakeholders to develop the capacity to enforce compliance with Codes more widely

Diagram 7: Indonesia: Governance and Regulatory Structure for Code Development



Sources: originally based on IPEEC 2015d and Gunawan et al. 2012 and, revised/updated through interviews

Malaysia

The factors impacting on building energy efficiency are outlined in Table 9 below.

Table 9: Malaysia: factors impacting on building energy efficiency

Population		
	Population (millions)	30.3
	Population density (persons per km^2)	92
Level and pace of urbanisation		
	1960	27%
	2015	75%
	% increase	178%
GDP and growth in household income		
	Purchasing power parity gross national income	$26,190
	Gross domestic product per capita % growth	3.5%
Energy supply – sources and growth in demand		
	Access to electricity: % of population	100.0%
	% renewable energy consumption	4.8%
	CO^2 emissions: per capita metric tons 2013	8.0

Climate zone	Tropical rainforest	
Sub-national/ private sector commitments	<u>Total commitments</u>: Emissions reduction - 14 Renewable energy - 6 Energy access & efficiency - 3 Use of carbon price – 2 Forest - 1	Short term pollutants - 1 Building - 1 Transport - 1 Resilience - 1
	<u>Cities (6)</u>: Kuching North, Melaka Historic City, Penang Island, Petaling Jaya, Seberang Parai, Shah Alam	
Energy policy packages	Malaysia's NDC is to reduce its greenhouse gas (GHG) emissions intensity of GDP by 45% by 2030 relative to the emissions intensity of GDP in 2005.	

Sources: The World Bank 2017; Global Climate Action 2017; Weather online 2017; UNFCCC 2017

In 1989 Malaysia launched its first energy efficiency standard for commercial buildings as a national voluntary guideline. This standard was subsequently revised and incorporated into Malaysian Standard MS 1525 as a voluntary code: Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-residential Buildings. The measures included in this Code include the building envelope, HVAC and lighting. In 2012, through an amendment of the Uniform Building By-Laws, MS 1525 was made mandatory for new or renovated non-residential buildings with air-conditioned space exceeding 4,000m^2. These building also had to be provided with an Energy Management System.

Two different federal government departments have responsibilities for developing building regulations and energy regulations: building regulations are the responsibility of the Ministry of Urban Wellbeing, Housing and Local Government, and; energy efficiency regulations are the responsibility of the Ministry of Energy, Green Technology and Water.

The national voluntary code is formally adopted and made mandatory by State governments who adapt and develop the code according to their particular circumstances. The implementation of any energy efficiency building code is the responsibility of local governments within Malaysia.

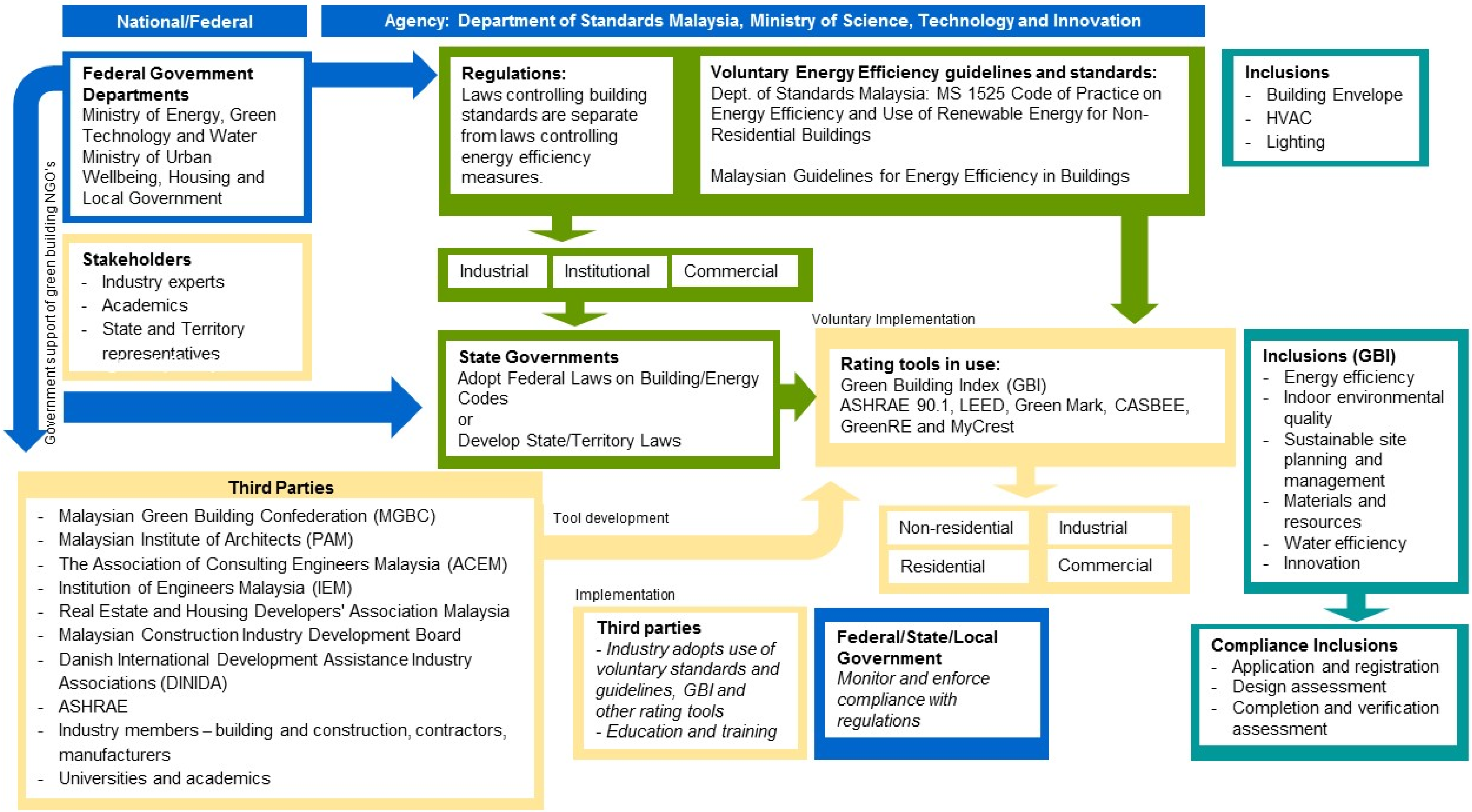
In 2009, the Malaysian Green Building Confederation (MGBC) introduced a voluntary rate tool, Green Building Index. GBI is supported by the Malaysian Institute of Architects, the Association of Consulting Engineers Malaysia as well as the Malaysian Government through the Ministry of Energy, Green Technology and Water, the Ministry of Science, Technology and Innovation and the Ministry of Works. Other voluntary rating tools used in Malaysia are ASHRAE 90.1 (from USA), LEED (from the United States Green Building Council), Green Mark (from Singapore), CASBEE (from Japan), GreenRE (from the Real Estate and Housing Developers' Association Malaysia) and MyCrest (from the Malaysian Construction Industry Development Board). Each of organisations sponsoring these voluntary rating tools conducts training on the use of the tool.

Diagram 8 below outlines the governance and regulatory structure for code development in Malaysia.

Issues and opportunities
The issues for Malaysia include:

- The development of a mandatory code which applies to both new and existing residential and commercial buildings and its adoption by the States;
- Complementary incentives in support of the Green Building Index for the construction of buildings which exceed a mandatory energy efficient building code;
- Develop a strategy for the implementation of a mandatory code including training, building capacity and enforce compliance;
- Develop a roadmap for future changes in Code;
- Work with state governments, local governments and other stakeholders to develop the capacity to enforce compliance with Codes more widely, and;
- Investigate the life cycle costs of energy efficiency measures.

Diagram 8: Malaysia: Governance and Regulatory Structure for Code Development



Sources: originally based on Chong 2013; Shaikah et al. 2017, Huang & Deringer 2007 and, revised/updated through interviews

The Philippines

The factors impacting on building energy efficiency are outlined in Table 10 below.

Table 10: The Philippines: factors impacting on building energy efficiency

Population		
	Population (millions)	100.7
	Population density (persons per km^2)	338
Level and pace of urbanisation		
	1960	30%
	2015	44%
	% increase	47%
GDP and growth in household income		
	Purchasing power parity gross national income	$8,940
	Gross domestic product per capita % growth	4.3%
Energy supply – sources and growth in demand		
	Access to electricity: % of population	89.1%
	% renewable energy consumption	28.7%
	CO^2 emissions: per capita metric tons 2013	1.0

Climate zone	Tropical rainforest	
Sub-national/ private sector commitments	Total commitments: Emissions reduction - 33 Resilience - 26 Renewable energy - 6 Forest - 5	Private finance - 4 Energy access & efficiency - 2 Short term pollutants - 1 Use of carbon price - 1
	Investors (1): Land Bank of the Philippines	
	Civil Society Organisations (1): Ecological Footprint Network Ecological Society of the Philippines	
Energy policy packages	The Philippines intends to undertake GHG (CO2e) emission reduction of about 70% by 2030 relative to its BAU scenario of 2000-2030. Reduction of CO2e emissions will come from energy, transport, waste, forestry and industry sectors. The mitigation contribution is conditioned on the extent of financial resources, including technology development & transfer, and capacity building, that will be made available to the Philippines.	

Sources: The World Bank 2017; Global Climate Action 2017; Weather online 2017; APEC Energy Working Group 2016

The Philippines introduced its first national Green Building code in 2015. Rather than going through a lengthy legislative process, the Secretary of the Department of Public Works and Highways (DPWH) used their authority to include the Green Building Code (GBC) as a referral code within the National Building Code. The Department partnered with the International Finance Corporation (IFC) in the development and implementation of the GBC.

The Green Building Code applies to all new construction and to additions, alterations, renovations and conversions to large buildings – above 10,000m^2. Designs and plans must comply with the requirements of GBC before a building permit is issued. After construction, building officials check the building as built against GBC before issuing an occupancy permit.

The Philippine Green Building Code built upon and scaled up an ordinance adopted by the City of Mandaluyong in 2014. In developing this ordinance, the City of Mandaluyong partnered with IFC for technical advice. Mandaluyong City has a separate green building unit which assesses the compliance of designs and plans against the ordinance prior to issuing a

Green Building Pre-Compliance Certificate (GBPCC). Upon completion of construction, a Green Building Certificate is issued upon proof of compliance with the GBPCC. The City of Mandaluyong also offers incentives to green developers by way of reduction on property taxes as well as increased percentage in the floor area ratio.

In addition to the mandatory Green Building Code, a number of voluntary rating codes are used by industry to certify buildings. Currently, there are two local certification systems – BERDE (developer-led) and GREEEN (professional-led) – and two international systems - the USGBC's LEED and IFC's EDGE. Of the certification systems, only EDGE is an international system which sets a global standard and, offers a free online tool to help developers make decisions on how to go green. The primary driver for the use of voluntary codes is the high cost of energy in the Philippines and the subsequent demand from tenants of buildings for better energy efficient buildings.

Diagram 9 below outlines the governance and regulatory structure for code development in the Philippines.

Issues and opportunities

The key issue for the Philippines is building technical and human resource capacity.

To regularly update the Green Building Code, the DPWH need to keep abreast of new technology and knowledge and what is happening in the local and international arena.

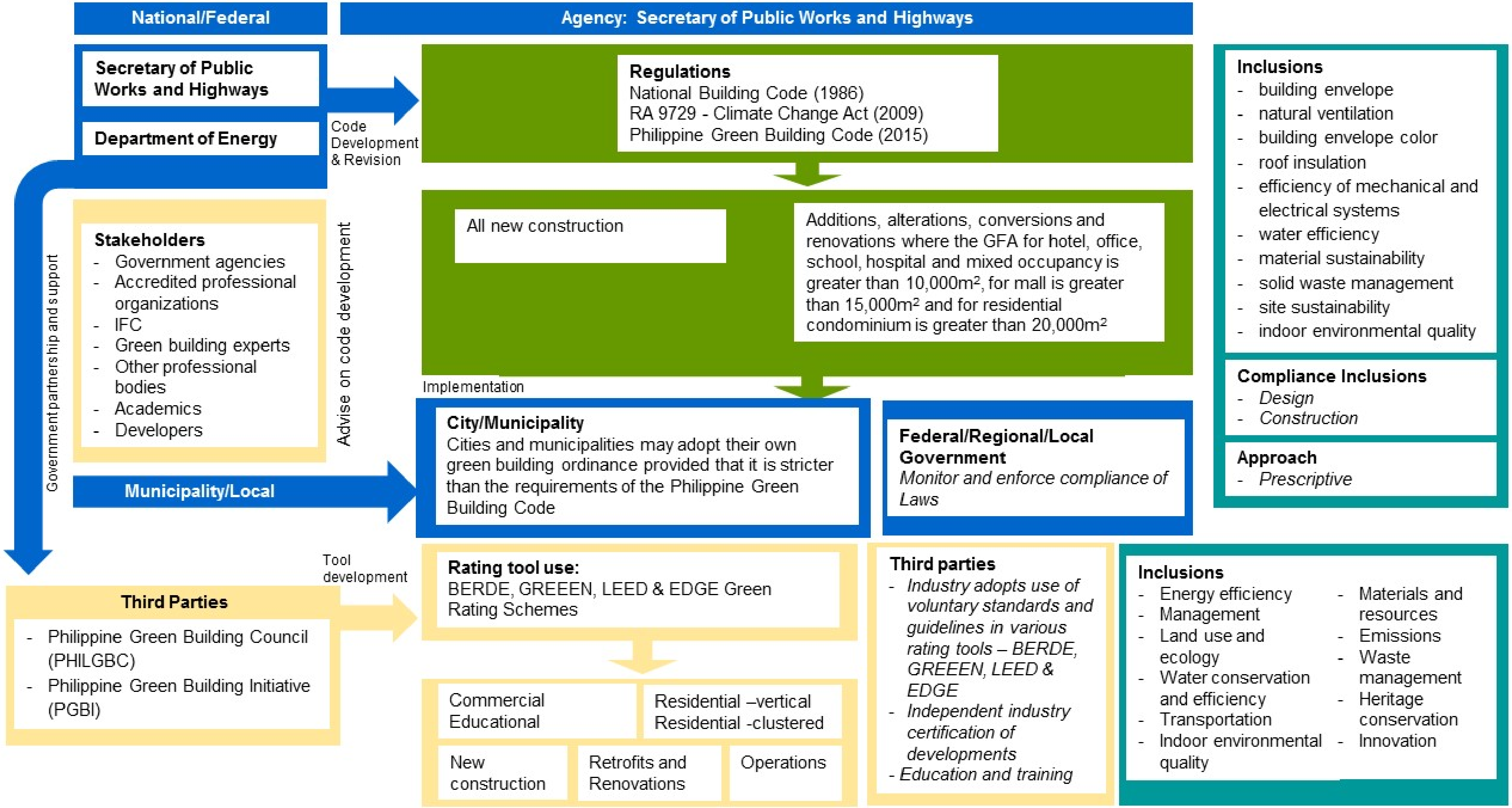
DPWH should also offer a regular (at least twice a year) intensive training on the implementation of the Green Building Code to building officials and developers. To monitor code implementation and development impact, they need to upgrade resources including the adoption of an e-platform for building permitting processes.

Other issues include:

- Revise the national building code so that it incorporates the Green Building Code;
- Developing a strategy for implementing the current Green Building Code;
- Providing a roadmap so that industry can transition into future requirements – given the lead-time on building projects, industry need to develop projects in view of future standards;
- Developers getting around Green Building code by staging proposed developments such that each is below the GFA threshold, and
- Mandatory disclosure of energy use to facilitate competition regarding building occupancy.

City governments within the Philippines (such as Quezon, Cebu, Mandaue and Santa Rosa) also have an interest in the APEC Low Carbon Model Town (LCMT) (see APEC 2017b).

Diagram 9: The Philippines: Governance and Regulatory Structure for Code Development



Sources: originally based on Chong 2013; Huang & Deringer 2007; Philippine Green Building Council 2017, Caringal 2016 and, revised/updated through interviews

Singapore

The factors impacting on building energy efficiency are outlined in Table 11 below.

Table 11: Singapore: factors impacting on building energy efficiency

Population		
	Population (millions)	5.5
	Population density (persons per km²)	7,807
Level and pace of urbanisation		
	1960	100%
	2015	100%
	% increase	0%
GDP and growth in household income		
	Purchasing power parity gross national income	$81,360
	Gross domestic product per capita % growth	0.8%
Energy supply – sources and growth in demand		
	Access to electricity: % of population	100.0%
	% renewable energy consumption	0.6%
	CO^2 emissions: per capita metric tons 2013	9.4

Climate zone	Tropical rainforest	
Sub-national/ private sector commitments	Total commitments: Emissions reduction - 21 Energy access & efficiency - 16 Forest - 10 Use of carbon price - 5 Private finance - 5	Building - 5 Renewable energy - 4 Resilience - 2 Other - 3
	Companies (2): Singapore Technologies Engineering, Singapore Telecommunications Limited	
Energy policy packages	Singapore intends to reduce its Emissions Intensity by 36% from 2005 levels by 2030 and stabilise its emissions with the aim of peaking around 2030	

Sources: The World Bank 2017; Global Climate Action 2017; Weather online 2017; APEC Energy Working Group 2016

Singapore developed its first set of building energy standards in 1979, as part of its energy conservation efforts for the building and construction sector. These standards addressed the thermal performance of building envelope and energy efficiency requirement for building services and equipment.

The Building and Construction Authority (BCA) is the government agency responsible for the development and implementation of the regulations governing these building energy efficiency standards. Over the years, BCA has been actively involved in the development of these standards in collaboration with Spring Singapore, the national standard body. The national standards (namely SS 530 and SS 553) developed, were incorporated as part of the compliance requirement to the extent as prescribed in the building regulations.

In 2008, BCA expanded its regulation regime by introducing a mandatory standard of environmental sustainability known as the Building Control (Environmental Sustainability) Regulations. This regulation requires developers and owners of new building projects as well as existing building projects involving major retrofitting or renovation (with GFA of 2,000m^2 or more) to meet the compliance standard which was modelled after the basic Green Mark certified standard. In support of this regulation, the Code for Environmental Sustainability of Buildings was developed and published, with subsequent revisions to keep abreast with advancement in technology and global trends.

This Code covers performance based requirements that necessitate the use of cost-effective energy saving technologies, design strategies, construction methods and operational monitoring as well as a higher energy efficiency standards for air-conditioning system. Compliance with the standard is required before building plan can be approved. Site audit may be conducted by BCA where needed to ensure that the design intent for environmental sustainability submitted is implemented before issuance of occupation permit.

In 2010, BCA mandates higher Green Mark standards under the Government Land Sales programmes of key development areas. New building development in these areas are required to meet the higher Green Mark standards (which comprises higher energy efficiency standard and requirement) as part of the land sale conditions.

From July 2013, building owners are required to submit their building information and energy consumption data annually to BCA. In the initial phase, only building owners with hotels, office buildings, retail buildings and mixed developments are required to submit data. The requirement has been further extended to other building types in phases.

Effective from Jan 2014, BCA has imposed a minimum environmental sustainability standard based on the requirement spelled out in the Code (namely the Code for Environmental Sustainability Measures for Existing Buildings) to improve the energy efficiency standard of these existing buildings. Building owners will need to ensure that their existing buildings meet this standard when they install or replace their building cooling system as part of their renovation. This helps ensure that existing buildings are equipped with better energy efficient building cooling systems and equipment when retrofitted.

As part of the post occupancy evaluations, the Code on Periodic Energy Audit of Building Cooling Systems) was introduced in 2014 to ensure existing buildings can and will continue operating efficiently through the building life cycle as per initial design. Building owners are required, upon notice to engage the services of a Professional Engineer (Mechanical) or an Energy Auditor registered with BCA to carry out an energy audit on the building cooling system and to make the energy audit report within stipulated timeframe for approval.
BCA supports the implementation of the Codes through its education arms (BCA Academy) which develops and delivers comprehensive training, education programs and courses. These programmes cater for to various needs from technical to professional levels.

In addition to the mandatory Code, BCA also promotes best practices through its BCA Green Mark Scheme certification. BCA has also put in place a building energy efficiency research and development roadmap to facilitate the development of technologies that have potential to achieve significant improvement in energy efficiency of buildings in Singapore.

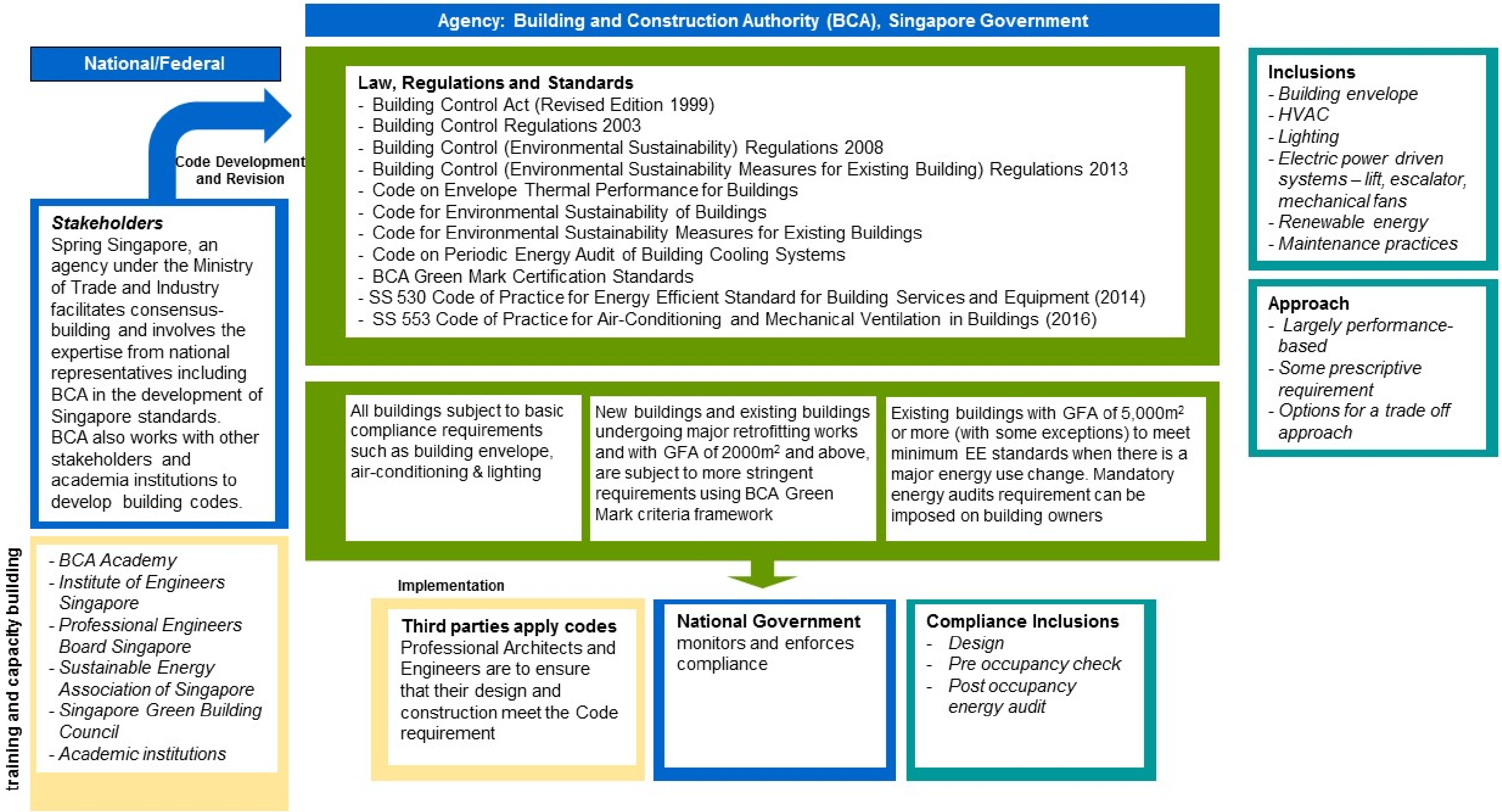
Diagram 10 below outlines the governance and regulatory structure for code development in Singapore.

Issues and opportunities

The issues for Singapore are:

- Development of cost-effective and proven technologies and solutions that have the potential to achieve significant improvement in building energy efficiency standards to meet its aspiration goal of “Positive energy low-rise, net Zero energy medium rise and super low energy high rise buildings”.

Diagram 10: Singapore: Governance and Regulatory Structure for Code Development



Sources: originally based on IPEEC 2015e and, revised/updated through interviews

Thailand

The factors impacting on building energy efficiency are outlined in Table 12 below.

Table 12: Thailand: factors impacting on building energy efficiency

Population		
	Population (millions)	68
	Population density (persons per km^2)	133
Level and pace of urbanisation		
	1960	20%
	2015	50%
	% increase	150%
GDP and growth in household income		
	Purchasing power parity gross national income	$15,520
	Gross domestic product per capita % growth	2.5%
Energy supply – sources and growth in demand		
	Access to electricity: % of population	100.0%
	% renewable energy consumption	23.6%
	CO^2 emissions: per capita metric tons 2013	4.5

Climate zones	Tropical savannah Tropical rainforest	
Sub-national/ private sector commitments	Total commitments: Emissions reduction - 79 Resilience - 17 Energy access & efficiency - 14 Renewable energy - 13 Use of carbon price – 7 Private finance - 3	Forest - 3 Short term pollutants - 3 Innovation - 1 Building - 1 Other - 2
Energy policy packages	Reduce energy intensity by 25% in 2030, compared with that in 2005	

Sources: The World Bank 2017; Global Climate Action 2017; Weather online 2017; APEC Energy Working Group 2016

Under its 20 year Energy Efficiency Plan (Thailand Ministry of Energy 2011), Thailand has committed to reducing energy intensity by 25% by 2030, compared with that in 2005.

Ministerial Regulation B.E. 2552 (2009) gives effect to the building energy code. This Code includes provisions for all government and state enterprise buildings and, for all other new and retrofitted buildings over 2,000m^2.

The Department of Alternative Energy Development and Efficiency within the Ministry of Energy (DEDE) is responsible for the development of the Code, as well as, promoting, supporting and disseminating knowledge and understanding of the Code among stakeholders.

In developing the Code, it works with other Ministries and consults with local governments, universities and academics and industry experts. DEDE has developed guidebook to assist in the implementation of Ministerial Regulation B.E. 2552. In support of the Code, DEDE has also developed a rating tool, Thailand Energy and Environmental Assessment Method (TEEAM), for residential and commercial buildings.

For government and state enterprise buildings, compliance with the Code is enforced by requiring them to have their building plans evaluated and certified by DEDE before funds will be allocated for construction. At the local/city level, compliance is the responsibility of local government or city government.

In addition, the Thai Green Building Institute has developed a voluntary code, Thailand Rating Energy and Environment System (TREES), for new buildings, renovations, commercial and residential high-rise and, for the labelling of products.

Diagram 11 below outlines the governance and regulatory structure for code development in Thailand.

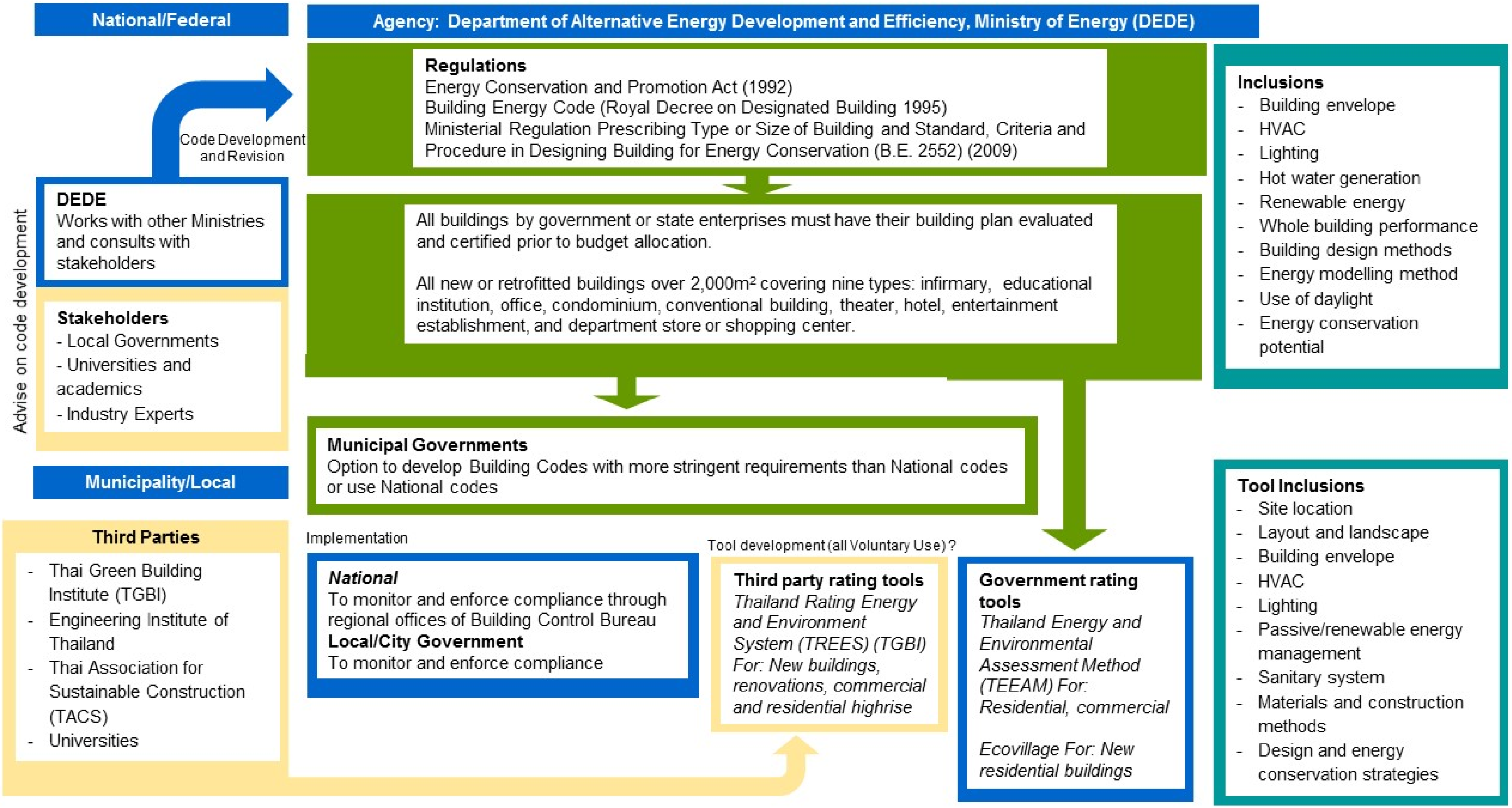
Issues and opportunities

The key issue for Thailand is that local authorities do not have the capabilities to implement and enforce the Code.

Other issues are:

- A strategy to implement the code;
- Man-power to implement the code and enforce compliance;
- Training of developers, government departments and state enterprises, local government inspectors in the Code;
- The cost of implementing the provisions of the Code, and
- Co-ordination between different Ministries.

Diagram 11: Thailand: Governance and Regulatory Structure for Code Development



Sources: originally based on IPEEC 2015; Chong 2013; Kim & Arnmanee 2014 and, revised/updated through interviews

Viet Nam

The factors impacting on building energy efficiency are outlined in Table 13 below.

Table 13: Viet Nam: factors impacting on building energy efficiency

Population		
	Population (millions)	91.7
	Population density (persons per km^2)	296
Level and pace of urbanisation		
	1960	15%
	2015	34%
	% increase	127%
GDP and growth in household income		
	Purchasing power parity gross national income	$5,720
	Gross domestic product per capita % growth	5.5%
Energy supply – sources and growth in demand		
	Access to electricity: % of population	99.2%
	% renewable energy consumption	36.2%
	CO^2 emissions: per capita metric tons 2013	1.7

Climate zones	Tropical savannah Humid subtropical	
Sub-national/ private sector commitments	Total commitments: Emissions reduction - 2 Transport - 1 Companies (1): Vietnam Railways (VNR)	Use of carbon price - 1 Forest - 1
Energy policy packages	Viet Nam's INDC identifies the GHG reduction pathway in the 2021 - 2030 period. With domestic resources, GHG emissions will be reduced by 8% by 2030 compared to the business-as-usual scenario The above-mentioned contribution could be increased up to 25% with international support	

Sources: The World Bank 2017; Global Climate Action 2017; Weather online 2017; APEC Energy Working Group 2016; UNFCCC 2017

The first Vietnamese Energy Efficiency Building Code (VEEBC), developed in 2005, was based in the ASHRAE 90.1 standard. However, the Code was too complex and so, was not implemented. After seven years further work based on experiences within Viet Nam, a revised simplified code was released in 2012-13. A third version of the Code is due to be released in 2017. The Code includes energy efficiency provisions which apply to commercial, public and residential dwellings over 2,500m^2.

The Central Government Ministry of Construction (MOC) is responsible for the development of the Code.

In addition to the mandatory Code, the Vietnam Green Building Council (VGBC) is actively promoting LOTUS as a rating tool for residential and non-residential buildings. To date, 20 commercial buildings and 5 residential buildings have been rated using LOTUS. EDGE is another rating tool that is used in Viet Nam.

The MOC and local government all conduct education and training in VEEBC, while VGBC provides training in LOTUS. In addition, the IFC developed user guidance, training material and pilot projects to support the implementation of VEEBC.

Diagram 12 below outlines the governance and regulatory structure for code development in Viet Nam.

Issues and opportunities
The key issue for Viet Nam is building capacity. This includes building knowledge of the Code and implications for developers; building expertise in assessing plans and conducting site inspections during and after construction; providing training for private developers and local government in the Code.

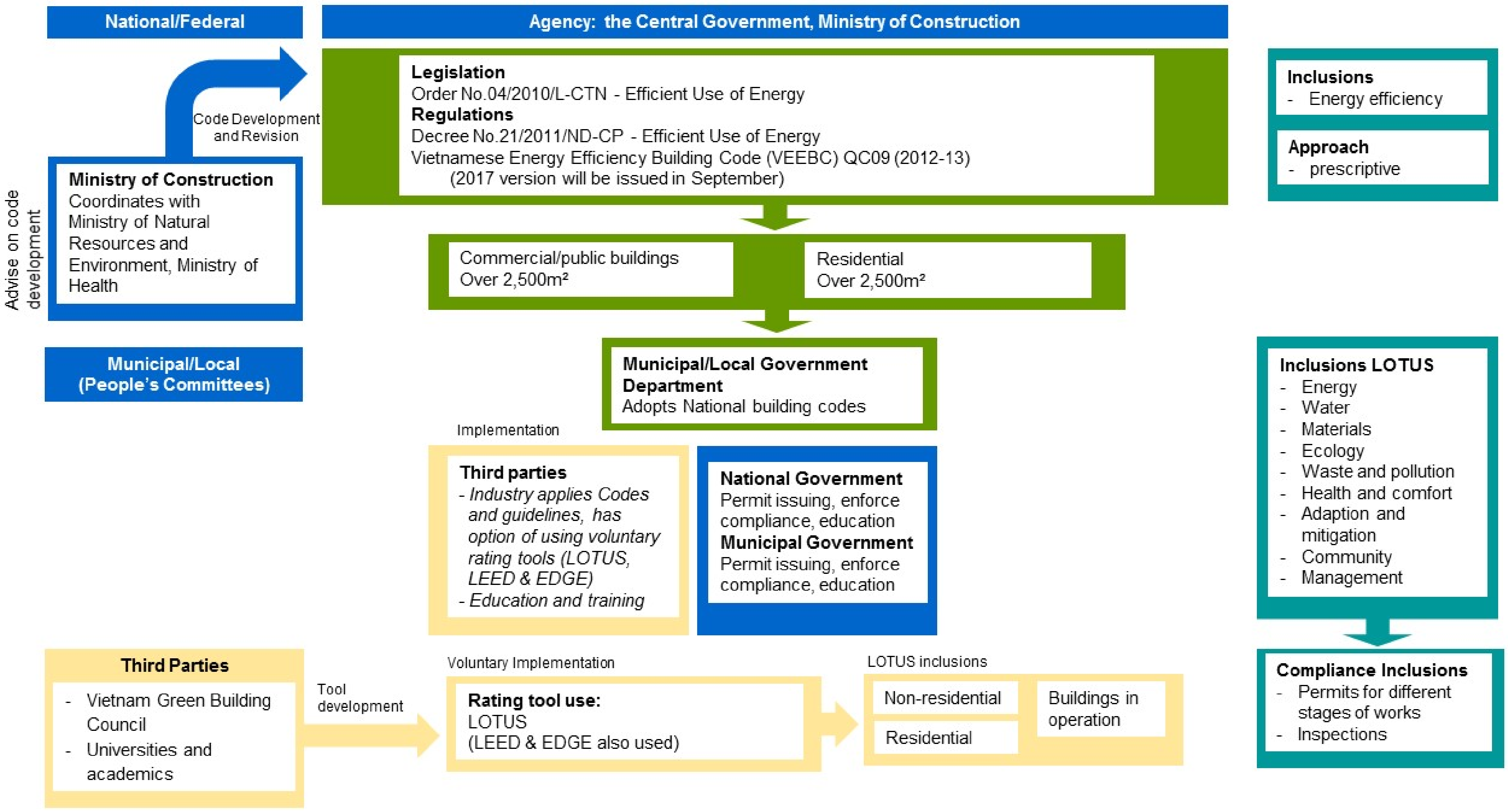
Other issues and opportunities include:

- Lack of capacity, particularly in local government to enforce compliance;
- Training for developers and for local government inspectors;
- The low price of energy in Viet Nam does not provide incentives for implementation of the Code;
- The code needs to simplified;
- The need for a phased implementation strategy which introduces technical specifications in key provinces and building capacity;
- Signalling longer term changes to the Code so that private developers and producers of building materials can prepare for them, and
- Enforcing compliance with the Code.

Priorities
Among the priorities for Viet Nam are:

- Revise the energy efficiency Law governing the Code and the Decree which guides the Law;
- Develop skills for assessing energy efficiency;
- Develop standards and guidelines;
- Develop the capacity of all stakeholders, and
- Pilot projects – office buildings, schools, shopping malls, high-rise residential.

Diagram 12: Viet Nam: Governance and Regulatory Structure for Code Development



Sources: originally based on IPEEC 2015; Chong 2013; Nguyen & Gray 2016 and, revised/updated through interviews

Appendix 2: Landscape of Building Energy Codes in APEC Economies

Table 14 below summarises the status of energy efficient building codes in APEC economies and highlights areas of success as well as areas for improvement.

A colour-coded ranking system highlights the extent to which APEC economies have developed each aspect required for best practice as follows:

	Comprehensive coverage	Addressed by 14 or more economies, unless more voluntary than mandatory measures are included
	Progress towards good coverage	Addressed by less than 14 or more than 7 economies, unless more voluntary than mandatory measures are included
	Significant gaps in coverage	Addressed by 7 or less economies
	Procedural processes which are not ranked	

Table 14: Summary of Energy Efficiency Building Codes in APEC Economies

	Australia	Brunei Darussalam	Canada	Chile	China	Hong Kong, China	Indonesia	Japan	Republic of Korea	Malaysia	Mexico	New Zealand	Papua New Guinea	Peru	The Philippines	Russia	Singapore	Chinese Taipei	Thailand	United States	Viet Nam
***Status of regulations:* (S=scheduled, U=unscheduled)**																					
Included in standard building codes/laws	●		●	●	●	●		●		●		●		●			●	●			
Included as a separate building code/law							●		●		●				●	●	●		●	●	●
Linked to a separate rating system	●		●		●	●	●	●	●	●	●	●			●		●	●	●	●	●
Only made mandatory at sub-national level	●		●	●			●	●	●	●	●			●			n.a.			●	
Currently being developed		●																			
Are reviewed regularly	U		U	?	S	U		U	U	U		S					U	U	U	U/S	U
Structural coverage: (● = Mandatory, e = covered with exemptions)																					
Commercial	●	●	●		●	●	e	●	●	●	e	●		e	e		●	●	●	●	e
Residential	●	e	●	●	e		e	●	●	e	e	●		e	e	e	●	●	e	●	e
Industrial		●	●				e	●	●	●	e	●					e	●	e	●	e
Other building types	●	●	●				e	●	●	●	e	●			e		●	●	e	●	
Technical requirements: (● = Mandatory, v = voluntary)																					
HVAC	●	v	●		●	v	●	●	●	●		●			●	v	●	●	●	●	●
Technical energy efficiency standards	●	v	●	v			●	●	●	v	●	●		●			●			●	●
Lighting	●	v	●		●	v	●		●	●				●	●	v	●		●	●	●
Building envelope	●		●	v	●		●			●	●			●	●		●	●	●	●	●

	Australia	Brunei Darussalam	Canada	Chile	China	Hong Kong, China	Indonesia	Japan	Republic of Korea	Malaysia	Mexico	New Zealand	Papua New Guinea	Peru	The Philippines	Russia	Singapore	Chinese Taipei	Thailand	United States	Viet Nam
Hot water	●		●	v	●				●			●			●		●	●		●	●
Maintenance					●												●	●			
Renewable energy	●		●		●					v				●			v	●		●	
Mechanical systems	●		●			v		●									●			●	●
Site/urban context			●		●	●	v	v	●			●			v		v	●		●	
Implementation																					
Software rating tools (● = Mandatory, v = voluntary)																					
Software tools developed/adopted by Government/Sub National government	●		●	v	●	v			●	●							●	●		●	
Software tools developed by third party and used informally			●			v	●	v		v	v	v			v		v		●	●	●
Compliance																					
Buildings are checked for energy efficiency compliance at: (G=by Government agency, T=Third party)																					
Design	G/T	G	G/T	G/T	G	G	G	G/T	G	T	G	G/T		G	G		G/T	G	G	G	G
Construction	G/T		G/T	G/T	G	G	G	G/T	G		G	G/T		G	G		G/T	G	G	G	
Pre occupancy	G/T			G/T	G		G				G			G	G		G/T			G	G
Post occupancy evaluation										T				G			G/T				

Notes:

Energy efficiency regulations and codes: The Republic of Korea, Singapore, Indonesia and The Philippines have green building codes; other economies have specific Laws, regulations or standards that are dedicated to energy efficiency in buildings (Chong 2013).

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List of Tables

List of Diagrams

Acronyms

APEC	Asia-Pacific Economic Cooperation
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BASIX	Building Sustainability Index (Australia)
BAU	Business as Usual
BCA	Building and Construction Authority (Singapore)
BEC	Building Energy Code
BEET	Buildings Energy Efficiency Task Group (IPEEC)
BERDE	Building for Ecologically Responsive Design Excellence
CABR	China Academy of Building Research
CASBEE	Comprehensive Assessment System for Built Environment Efficiency (Japan)
CSTID	Center of Science and Technology and Industrialization Development
DANIDA	International Development Agency of Denmark
DPWH	Department of Public Works and Highways (The Philippines)
EDGE	Excellence in Design for Greater Efficiencies
EE	Energy Efficiency
GABC	Global Alliance for Buildings and Construction
GB	Green Building
GBCI	Green Building Council Indonesia
GBI	Green Building Index (rating tool)
GBPCC	Green Building Pre-Compliance Certificate (The Philippines)
GBPN	Global Buildings Performance Network
GDP	Gross Domestic Product
GFA	Gross Floor Area
GHG	Greenhouse Gas
GREEEN	Geared for Resiliency and Energy Efficiency for the Environment
HAKE	Association of Energy Conservation Experts (Indonesia)
HVAC	Heating, Ventilation and Air conditioning
IEA	International Energy Agency
IECC	International Energy Conservation Code
IFC	International Finance Corporation
INDCs	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
IPEEC	International Partnership for Energy Efficiency Cooperation
LEED	Leadership in Energy and Environmental Design
MGBC	Malaysian Green Building Confederation
MoE	Ministry of Environment (Indonesia)

MOHURD	Ministry of Housing and Urban-Rural Development (China)
MyCREST	Malaysian Carbon Reduction and Environmental Sustainability Tool
NABERS	National Australian Built Environment Rating System
NAMA	Nationally Appropriate Mitigation Actions (UNEP)
NatHERS	Nationwide House Energy Rating Scheme
NAZCA	Non-State Action Zone for Climate Action
NCC	National Construction Code (Australia)
NDC	Nationally Determined Contribution
NEPP	National Energy Productivity Plan (Australia)
NHSC	National Housing Supply Council (Australia)
NZEB	Nearly-Zero Energy Building (Net-Zero Energy Building in some countries)
PGBI	Philippine Green Building Initiative
PHILGBC	Philippine Green Building Council
SDG	Sustainable Development Goal
SE4All	Sustainable Energy for All (UN)
SNI	Standards National Indonesia
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
USGBC	United States Green Building Council
VBA	Victorian Building Authority (Australia)
VEEBC	Vietnamese Energy Efficiency Building Code
WRI	World Resources Institute (USA)