Global Alliance for Buildings and Construction

GlobalABC Regional Roadmap for Buildings and Construction in Asia

2020-2050

Towards a zero-emission, efficient, and resilient buildings and construction sector

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for Buildings and
Construction

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Table of contents

Executive summary **9**
Getting to zero-emission, efficient and resilient buildings by 2050 11
Key actions and strategy 11
How to use the regional roadmap document **15**
Introduction **19**
Decarbonising the buildings sector 20
Asia overview **22**
Energy and emissions 22
Regional context: Asia 26
Targets and timelines **31**
Activity 1: Urban planning 31
Activity 2: New buildings 45
Activity 3: Existing buildings 61
Activity 4: Building operations 73
Activity 5: Appliances and systems 83
Activity 6: Materials 95
Activity 7: Resilience 109
Activity 8: Clean energy 121
Roadmap support: Enablers 135
Conclusions and outlook **144**
References **146**
Resources **153**
Acronyms, abbreviations and units of measure **155**
Annex **157**

Table of figures

Figure 1 • Building codes in Asia, 2017-18 10
Figure 2 • Asia roadmap summary timelines 11
Figure 3 • Demonstration timeline 16
Figure 4 • Whole-life carbon: Definitions, adapted from European standard EN 15978 21
Figure 5 • Share of buildings final energy and emissions in ASEAN, China and India, 2018 22
Figure 6 • Emissions from buildings in ASEAN, China and India 2018 and in 2040 under the IEA STEPS and SDS 23
Figure 7 • Final energy consumption in buildings in ASEAN, China and India to 2040 in the SDS, and % share in 2040 23
Figure 8 • The evolution of the electricity generation mix in ASEAN, China and India to 2040 in the SDS, and % share in 2040 24

Figure 9 • Possible reductions in material demand and CO_2 emissions reductions in buildings under the Material Efficiency Scenario compared with the Reference Technology Scenario by 2060 (global) 25
Figure 10 • Building energy codes by jurisdiction, 2017-18 28
Figure 11 • Building energy certification programmes by jurisdiction, 2017-18 28
Figure 12 • Building sector emissions coverage in NDCs by jurisdiction, 2017-18 29
Figure 13 • Key actions for urban planning in Asia 32
Figure 14 • Policy timelines for urban planning in Asia 34
Figure 15 • Technology timelines for urban planning in Asia 38
Figure 16 • Key actions for new buildings in Asia 46
Figure 17 • Policy timelines for new buildings in Asia 48
Figure 18 • Technology timelines for new buildings in Asia 52
Figure 19 • Key actions for existing buildings in Asia 62
Figure 20 • Policy timelines for existing buildings in Asia 63
Figure 21 • Technology timelines for existing buildings in Asia 66
Figure 22 • Key actions for building operations in Asia 74
Figure 23 • Policy timelines for building operations in Asia 75
Figure 24 • Technology timelines for building operations in Asia 77
Figure 25 • Key actions for appliances and systems in Asia 84
Figure 26 • Policy timelines for appliances and systems in Asia 85
Figure 27 • Technology timelines for appliances and systems in Asia 87
Figure 28 • The WorldGBC's scope and definition of the building life cycle 95
Figure 29 • Key actions for materials in Asia 97
Figure 30 • Policy timelines for materials in Asia 99
Figure 31 • Technology timelines for materials in Asia 102
Figure 32 • Key actions for resilience in Asia 111
Figure 33 • Policy timelines for resilience in Asia 112
Figure 34 • Technology timelines for resilience in Asia 115
Figure 35 • Key actions for clean energy in Asia 122
Figure 36 • Policy timelines for clean energy in Asia 124
Figure 37 • Technology timelines for clean energy in Asia 127
Figure 38 • Key actions for capacity building in Asia 136
Figure 39 • Timelines for capacity building actions 136
Figure 40 • Key actions for finance in Asia 139
Figure 41 • Participants to the Asia Roadmap process 157

Table of tables

Table 1 • Roadmap definitions15
Table 2 • Stakeholder mapping for urban planning in Asia 33
Table 3 • Capacity building for urban planning in Asia 42
Table 4 • Multiple benefits of urban planning 43
Table 5 • Stakeholder mapping for new buildings in Asia 47
Table 6 • Capacity building for new buildings in Asia 56
Table 7 • Multiple benefits of new buildings 58
Table 8 • Stakeholder mapping for existing buildings in Asia 62
Table 9 • Capacity building for existing buildings in Asia 69
Table 10 • Multiple benefits of existing buildings 70
Table 11 • Stakeholder mapping for building operations in Asia 74
Table 12 • Capacity building for building operations in Asia 79
Table 13 • Multiple benefits of sustainable building operations 80

Table 14 • Stakeholder mapping for appliances and systems in Asia 84
Table 15 • Capacity building for appliances and systems in Asia 91
Table 16 • Multiple benefits of sustainable building systems 92
Table 17 • Stakeholder mapping for materials in Asia 98
Table 18 • Capacity building for materials in Asia 105
Table 19 • Multiple benefits of sustainable materials 106
Table 20 • Stakeholder mapping for resilience in Asia 111
Table 21 • Capacity building for resilience in Asia 118
Table 22 • Multiple benefits of resilient buildings 119
Table 23 • Stakeholder mapping for clean energy in Asia 123
Table 24 • Capacity building for clean energy in Asia 131
Table 25 • Multiple benefits of clean energy 132
Table 26 • Types of capacity building across activities 138
Table 27 • Stakeholder mapping across activities 142

Table of boxes

Box 1 • Urban planning in Asia: Trends and challenges 31
Box 2 • Regional examples of policy action for urban planning 37
Box 3 • Regional examples of technologies for urban planning 40
Box 4 • New buildings in Asia: Trends and challenges 45
Box 5 • What is a building code? 50
Box 6 • Regional examples of policy action for new buildings 51
Box 7 • Examples of regional technologies for new buildings 55
Box 8 • Existing buildings in Asia: Trends and challenges 61
Box 9 • Regional examples of policy action for existing buildings 65
Box 10 • Regional examples of technologies for existing buildings 68
Box 11 • Building operations in Asia: Trends and challenges 73
Box 12 • Regional examples of policy action for building operations 76
Box 13 • Regional examples of technologies for building operations 78
Box 14 • Appliances and systems in Asia: Trends and challenges 83
Box 15 • Regional examples of policy action for appliances and systems 86
Box 16 • Regional examples of technologies for appliances and systems 90
Box 17 • Materials in Asia: Trends and challenges 96
Box 18 • Regional examples of policy action for materials 101
Box 19 • Regional examples of technologies for materials 104
Box 20 • What is a resilient city? 109
Box 21 • Resilience in Asia: Trends and challenges 110
Box 22 • Regional examples of policy action for resilience 113
Box 23 • Regional examples of technologies for resilience 116
Box 24 • Clean energy in Asia: Trends and challenges 121
Box 25 • Regional examples of policy action for clean energy 126
Box 26 • Regional examples of technologies for clean energy 129
Box 27 • Enabling activities in Asia: Trends and challenges 135
Box 28 • Examples of regional action on capacity building 138
Box 29 • Examples of regional action on finance 140
Box 30 • Examples of mechanisms to facilitate institutional co-ordination 143
Box 31 • The GlobalABC 145

Executive summary

With the Paris Agreement countries have agreed to a common goal of maintaining the global temperature increase to well below 2 degrees, and preferably no more than 1.5 degrees, by the end of the century. According to the latest UNEP Emissions Gap report, to be on track for the 1.5 degree goal, the world needs to reduce global emissions by over 50% by 2030 and work towards carbon neutrality by 2050. As the buildings and construction sector accounted for 36% of final energy use and 39% of energy and process-related carbon dioxide (CO_2) emissions, globally, in 2018, it will have to play a major part in achieving this vision.

In 2018, the buildings sector in the Association of Southeast Asian Nations (ASEAN), the People's Republic of China (hereafter "China") and India accounted for 27% of the region's final energy use and 24% of energy-related carbon dioxide (CO_2) emissions, excluding emissions from manufacturing building materials (IEA, 2019a). Since 2010, growth in regional energy demand has been driven by a 7% increase in population and a 70% increase in wealth (gross domestic product) which has in turn increased demand for floor area and energy consuming services. Continued growth in floor area is expected in the region which could represent nearly half of the new construction in the world by 2040 (OECD/IPEEC, 2018).

Decarbonising buildings across the entire life cycle would require a transformation of the buildings and construction sector. Reaching net-zero operational and embodied carbon emission buildings is possible, but requires clear and ambitious policy signals to drive a range of measures including passive building design, material efficiency, low-carbon materials, efficient building envelope measures, and highly efficient lighting and appliances.

According to the *World Energy Outlook*, energy efficiency and the decarbonisation of electricity under a Sustainable Development Scenario[1] could reduce annual emissions from buildings in Asia in 2040 by almost 3 000 megatonnes of carbon dioxide ($MtCO_2$) compared to a Stated Policies Scenario[2] (IEA, 2019a). Material efficiency could bring significant additional reductions in greenhouse gas (GHG) emissions in the material lifecycle of buildings, with potential reductions of over 80% in China and 50% in India for residential buildings (IRP, 2020).

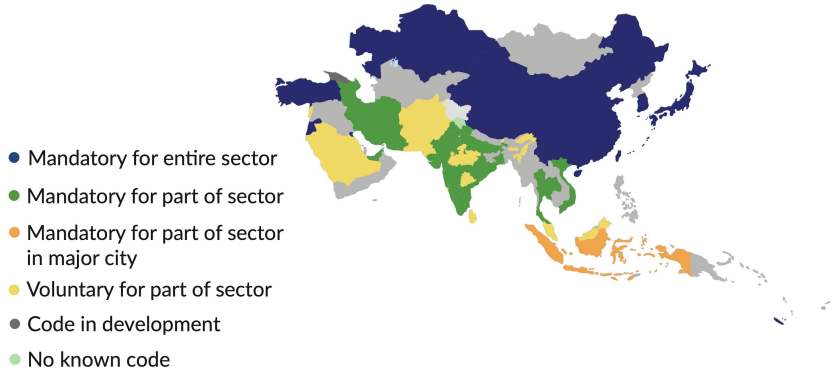
Achieving these outcomes at pace and scale will require greater collaboration among policy makers at all jurisdictional levels, as well as with urban planners, architects, developers, investors, construction companies and utility companies. In addition to providing healthier, more resilient and more productive environments, the decarbonisation of the buildings sector presents a business opportunity in East Asia Pacific and South Asia with an estimated value of approximately USD 17.8 trillion by 2030 (IFC, 2019). Decarbonising buildings is also in full alignment with the aims of SDG 12, to ensure sustainable consumption and production patterns.

Across the Asian region, however, progress on building energy codes is not keeping up with the considerable growth in demand for new buildings. Less than half of countries in Asia have mandatory or voluntary building codes or certification programmes in place (Figure 1).

[1] As well as meeting the energy-related UNFCC Sustainable Development Goals in full, the Sustainable Development Scenario (SDS) is fully aligned with the Paris Agreement, holding the global average temperature rise to below 1.8°C with a 66% probability without reliance on global net-negative CO_2 emissions.

[2] The Stated Policies Scenario (STEPS) reflects the impact of existing policy frameworks and today's announced policy intentions.

Figure 1 • Building codes in Asia, 2017-18



Note: This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city or area.

Source: GlobalABC/IEA/UNEP (2019), *2019 Global Status Report for Buildings and Construction: Towards a Zero-Emission, Efficient and Resilient Buildings and Construction Sector.*

The purpose of this roadmap is to support a common language and vision for the complete decarbonisation of buildings across their life cycle and to support the development of national or subnational strategies and policies, including for example, Nationally Determined Contributions (NDCs). It outlines the range of actions that stakeholders can take in the short, medium and long term to achieve a built environment that is zero-emission, efficient and resilient.

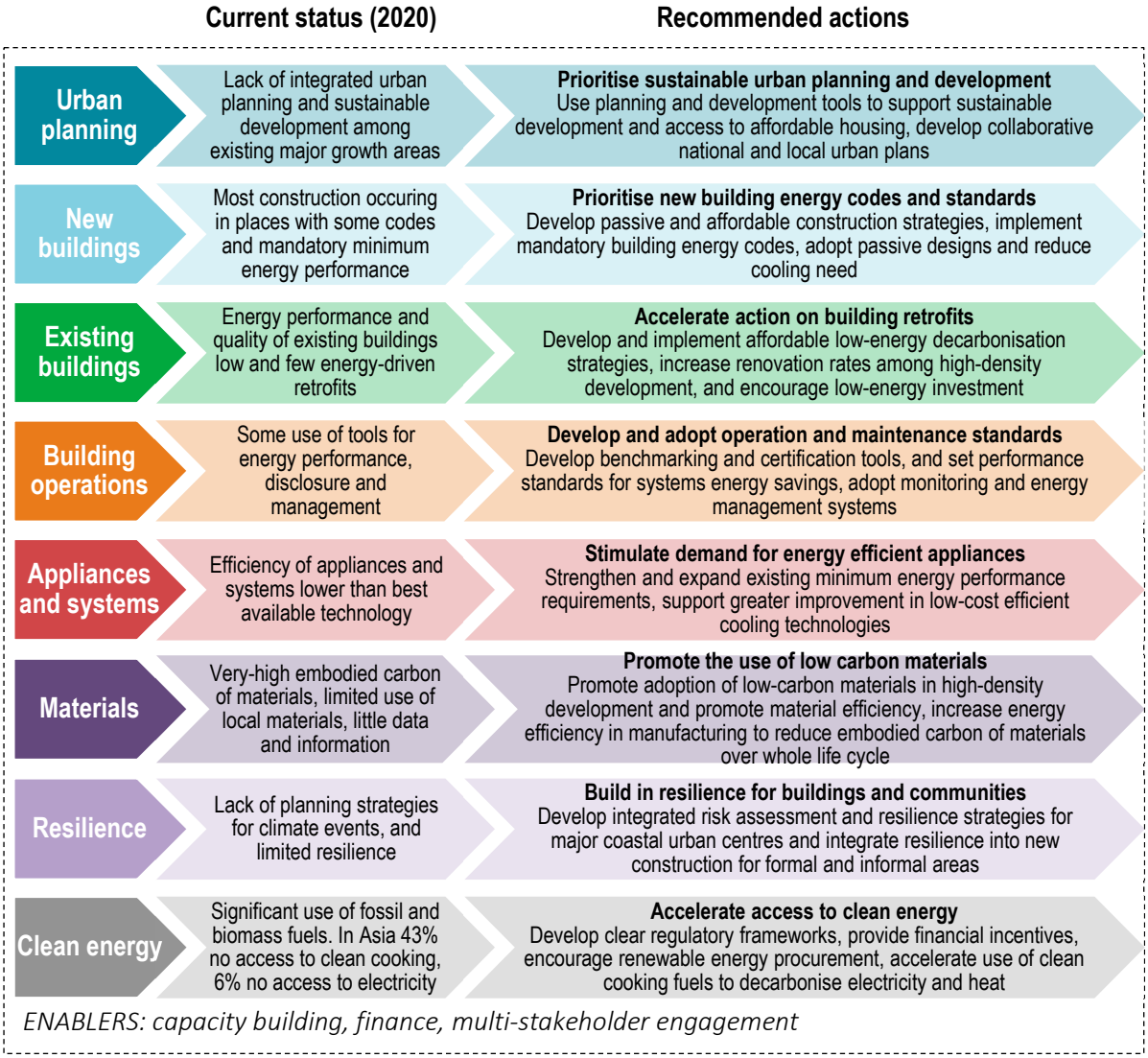
It covers eight "activities": urban planning, new buildings, existing buildings, building operations, appliances and systems, materials, resilience and clean energy, and for each of these proposes key actions, targets for policies and technologies, and enabling measures with the aspiration of reaching net-zero carbon emission buildings by 2050.

The Asia Roadmap builds on consultation with over 200 stakeholders and buildings experts across the region who provided input to collectively build the timelines across the eight activities.

Getting to zero-emission, efficient and resilient buildings by 2050

The timelines below describe the actions identified by stakeholders as being key to delivering zero-emission, efficient and resilient buildings in Asia by 2050. The chapters "Activities 1-8" and "Roadmap support: Enablers" develop the strategies that support the delivery of these objectives.

Figure 2 • Asia roadmap summary timelines



Key actions and strategy

To support decarbonising new and existing buildings, effective policies and regulations need to cover the entire building lifecycle, including the design, development, operation and decommissioning stages, and also act beyond site boundaries through neighbourhood planning and clean energy. To accelerate action, greater collaboration involving a range of stakeholders is needed, including policy makers, urban planners, architects, construction companies, materials suppliers, utility companies, developers and investors.

Based on extensive stakeholder consultation and analysis, the following actions would need to be undertaken in order to achieve progress towards zero-emission, efficient and resilient buildings.

National roadmaps and strategies set priorities for the sector

National ministries and city agencies should develop ambitious, comprehensive strategies and roadmaps to outline the pathway to a zero-emission, efficient and resilient buildings and construction sector. These strategies should be developed through consultation and engagement that brings in a range of disciplines of urban planning, building design and construction, materials, resilience and clean energy. These strategies should focus on early action due to the current high construction rates in Asia and address the data and ambition gaps identified in this roadmap.

Governments and industry coalitions should work to close key information gaps on building performance by establishing data collection systems and methodologies, particularly given the large number of high-density developments constructed across the region. Such data can provide essential evidence to inform decarbonisation and efficiency planning and underpin the quantifiable benefits of efficiency and sustainability interventions.

Ministries should develop national and local renovation and financing strategies to accelerate implementation and achievement of decarbonisation and energy savings goals, such as increasing the annual energy efficiency renovation rate to 2% by 2040.

Local and regional government agencies should undertake risk mapping and resilience assessment and develop integrated strategies to improve the resilience of the building stock. The region is at high risk of sub-tropical climate events and fast-growing centres require strategies to address resilience risks in new building developments and informal settlements. Such actions should also map and develop strategies for adapting existing buildings to mitigate against extreme climate events and changes in climatic conditions.

Standards and codes gradually drive up performance

Regulators can reduce future energy demand in new buildings through progressive mandatory energy codes that in particular focus on adopting standards for building fabric performance, and include replicable and locally adapted strategies for mitigating cooling demand, such as passive design, natural ventilation, insulation, shading, and low-emissivity windows.

Regulators should develop and expand minimum energy performance standards (MEPS) to set ambitious product energy performance requirements covering all major appliances and systems. MEPS in the region can be further integrated and aligned to support collaboration across the region to enable cross-border applicability.

Regulatory frameworks to facilitate integrated action

City-level actors should collaborate across sectors and government levels to manage the considerable growth in large urban centres to develop integrated urban planning policies and frameworks that address equitable and sustainable land use, transit-oriented design, accessible greenspace, climate resilience and district clean energy planning.

National and local agencies should develop ambitious regulatory and incentive frameworks to increase investment in energy efficiency improvements or reduce carbon emissions from the production of major building materials.

National and local agencies should develop clear regulatory and incentive frameworks to promote the use of on-site and building-integrated renewable energy, including solar PV, solar thermal, geothermal, micro-wind and advanced biofuels where appropriate. Frameworks should define the operational framework, incentives, and integration mechanisms at the national and local level.

Narratives and engagement to drive demand

National governments should raise the level of ambition in narratives and quantitative targets on actions that support zero carbon emission building performance and construction methods. Building collective efforts to respond to the challenge of improving the new and existing buildings across Asia needs to align with the scale of construction activities and ambitious social and economic change across the region.

Governments and large organisations can take leadership in zero-carbon procurement and standards to promote investment in low-carbon building construction and renovation among their headquarters and building stock and encourage adoption of efficient technologies at scale.

Governments should promote the use of regular energy performance auditing and data collection to ensure the effectiveness and performance of building energy performance interventions and encourage active engagement with building rating schemes.

Capacity building

Governments and industry coalitions should promote opportunities for capacity building on topics like embedding circular economy concepts into buildings through life-cycle approaches, data collection for efficiency improvement, reuse of construction materials, and phasing out high global warming potential refrigerants.

Finally, government and industry coalitions should promote the adoption of existing efficient building construction and operation techniques and low-cost technologies that can improve building performance and lower embodied carbon.

Building on the Asia Roadmap findings: Address gaps and raise ambition

Address key information gaps by collecting data and evidence to support actions to decarbonise and improve the efficiency of buildings. Across Asia, information was found to be lacking on integrated and spatial urban planning policies and activities, informal development activities, the use of space and water heating technologies, use of smart devices, the carbon content of materials; risk mapping; and decentralised renewables deployment. Putting in place systems to capture this information will allow for greater certainty around the impacts that policies and markets are having.

Raise the level of ambition on actions that can support improved building performance and construction methods that matches the scale of development change. There is a reported lack of ambition in advancing the use of spatial planning approaches, bioclimatic design principles and low-energy building system technologies; building code adoption and compliance; building labelling and benchmarking; use of audit and building management tools; and integrated building renewables. Increasing effort to respond to the challenge of improving the new and existing buildings across Asia needs to align with the ambitious construction activities and the scale of social and economic change across the region.

How to use the regional roadmap document

This section describes how to read the document and how to interpret the targets and timelines.

This document is intended to identify common goals, targets and timelines for key actions across eight "activities". Each activity represents a segment of the buildings and construction sector: urban planning, new buildings, existing buildings, appliances and systems, building operations, materials, resilience and clean energy as each of these represents a key ingredient of how buildings influence our environment and vice-versa.

Table 1 • Roadmap definitions

Activity 1: **Urban planning**. This activity covers land use, zoning and other planning associated with the buildings, transport and energy systems interact.

Activity 2: **New buildings**. This activity covers all aspects of new buildings, including the design process, design strategies, codes and labels.

Activity 3: **Existing buildings**. This activity covers all aspects of the improvements of existing buildings.

Activity 4: **Building operations**. This activity covers all aspects of the operations and management of buildings.

Activity 5: **Appliances and systems**. This activity covers lighting, appliance and equipment systems that are used in both new and existing buildings.

Activity 6: **Materials**. This activity covers envelope, structural and product materials used in buildings.

Activity 7: **Resilience**. This activity covers all aspects of building resilience that enables increased capacity to adapt to and mitigate the effects of changing climates and other natural disasters.

Activity 8: **Clean energy**. This activity covers the clean energy transition away from carbon-intensive fuels to renewable energy resources.

Roadmap support: **Enablers**. These constitute the key success factors for capacity building, financial tools and multiple benefits and how they can support the achievement of the targets and timelines for the activities.

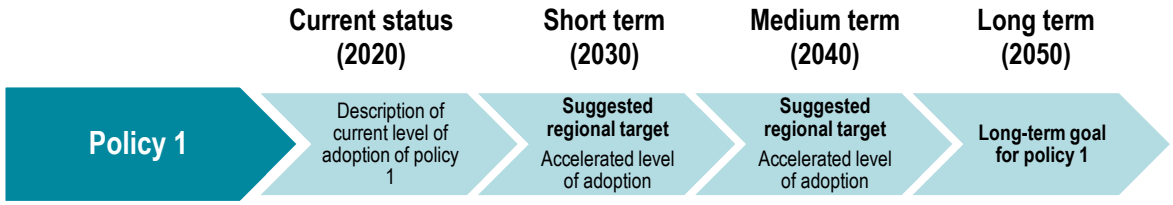
Each of the activities is structured in a similar manner, illustrated by relevant examples, and can be read either in isolation or in conjunction with the other parts of the document.

Each of the activities covers:

- **Key actions**: a summary of key actions and timelines identified for the activity.
- **Stakeholders**: a map of the different stakeholders relevant to the activity and their relative importance.
- **Recommended policy action**: a list of recommended policies with a description of the current status of that policy in the region, and proposed targets for the short, medium and long term. These are shown as a set of timelines, with a description of each below. See note below about how to read the timelines.
- **Recommended technology action**: a list of recommended actions related to particularly technologies, with a description of the current status of that technology in the region, and proposed targets for the short, medium and long term. These are shown as a set of timelines, with a description of each below. See note below about how to read the timelines.
- **Finance action**: a list of recommended financial tools particularly relevant to the activity, followed by a series of local examples of current practice.
- **Capacity building**: a list of recommended capacity-building actions particularly relevant to the activity, followed by a series of local examples of current practice.
- **Multiple benefits**: a catalogue of the types of multiple benefits most relevant to the activity.

Figure 3, and the paragraph that follows, provides guidance on how to interpret the timelines:

Figure 3 • Demonstration timeline



Note: The **proposed regional target** is in **bold**. Below that is the proposed accelerated target.

The target written in bold represents a regional target. The accelerated, given below the regional target, represents a "stretch target" to be aimed for by countries able to go further, quicker. The 2050 target represents the ultimate desired, long-term outcome. Some indicators do not contain accelerated targets due to a lack of data or input. The targets serve to represent a goal or milestone towards the longer-term objective.

These targets and key actions were proposed based on a wide stakeholder consultation with local building actors, as well as the expertise of the authors and evidence from the global and regional building community.

Stakeholder consultation took the form of questionnaires, in-person workshops, webinars and phone conversations, and included engagement with over 200 people.

Below each of the timelines, a description of each policy or technology item outlines the following:

- **Policy type 1:** Description of how the policy works and what the key success factors are for successful implementation. *Description of how the stakeholders consulted believe it will evolve over time, based on their experience of the market*.

Where there is a significant gap between the target and what stakeholders believed to be achievable, the item has been marked with a **red bullet**, as a way of highlighting it as a priority area for action. Where there was a lack of data or a lack of consensus, the item has been marked with an **orange bullet**, denoting the need for additional consultation and/or data**.**

These timelines and targets serve to raise ambition and to frame sub-regional or national roadmap development.

The Regional Roadmap is a LIVING document for Asia that can be adapted over time to support sub-regional and local roadmap needs and adapt to trends in the buildings and construction sectors.

This roadmap is the product of multiple workshops, webinars, surveying and conversations with experts across Asia, and included the views of over 200 people. The input included: 135 regional stakeholders provided input in-person via two events, 55 responded to the survey, and another 25 participated in webinars.

Introduction

The year 2015 was pivotal in addressing the critical need to tackle climate change, with the adoption of the Sendai Framework for Disaster Risk Reduction, the 2030 Agenda for Sustainable Development and the Paris Agreement reached at the 21st Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC). Decarbonising the buildings and construction sector has a significant role to play in achieving these objectives and the related SDGs.

The buildings and construction sector is responsible 36% of final energy demand globally, representing 39% of energy- and process-related emissions. Climate scenarios show that emissions in this sector will have to be significantly reduced in order to achieve the Paris Agreement goals. Yet the *2019 Global Status Report* of the GlobalABC highlights that today's progress on emissions reductions are not on track as energy efficiency improvements are outpaced by floor area and demand growth. To counteract these trends, the global average building energy intensity per unit of floor area would need to be at least 30% lower than 2018 levels by 2030.

As identified in the *2019 Global Status Report for Buildings and Construction*, and the *Guide for incorporating buildings actions in NDCs*, actions such as improving sustainable material choices and building design; urban planning measures, adaptation and resilience plans; clean energy transitions; and building operations and renovation all provide opportunities to realise the goals of the Paris Agreement, i.e. to maintain the global temperature increase well below 2 degrees, and preferably below 1.5 degrees, by the end of the century.

The buildings and construction sector is a highly "local" and "fragmented" industry, with no single group of large businesses having significant control of the stock and value chain. Innovation is slow, largely due to this fragmentation, and there is a lack of a common and international vision from the disparate actors in the buildings sector. Thus, this roadmap aims to facilitate a common language and vision, foster transparency, promote inclusion and co-operation among these stakeholders to implement effective long-term policies, and integrate emerging and innovative technologies into everyday practices.

This roadmap is the result of a stakeholder-driven process in which buildings experts around the world were consulted and provided input to collectively build the timelines for each of the activities. These serve as a framework for the buildings and construction sector to align with the climate related objectives set out in the Paris Agreement. The GlobalABC Regional Roadmaps for Africa, Asia and Latin America cascade this methodology for the regions, incorporating relevant key insights and examples of best practice.

As a regional document, there is great diversity in terms of climate, buildings culture, baseline starting points and data availability. Countries are represented in the roadmap according to the extent of the available information.

This roadmap intends to guide policy makers when designing their national buildings and climate strategies, for example when undertaking a review of their 2020-25 nationally determined contributions (NDCs). It aims to identify goals and milestones, and to help organisations in determining their long-term and medium-term investment strategies. It does not replace a more detailed national or local buildings and construction roadmap that would take into account individual country circumstances.

Decarbonising the buildings sector

The buildings sector will play a major role in supporting the decarbonisation of the global economy, through improvements in energy efficiency to reduce energy demand, reducing use of materials and in so doing, reducing the embodied carbon, and finally, by supporting adoption of distributed low-carbon and renewable energy generation.

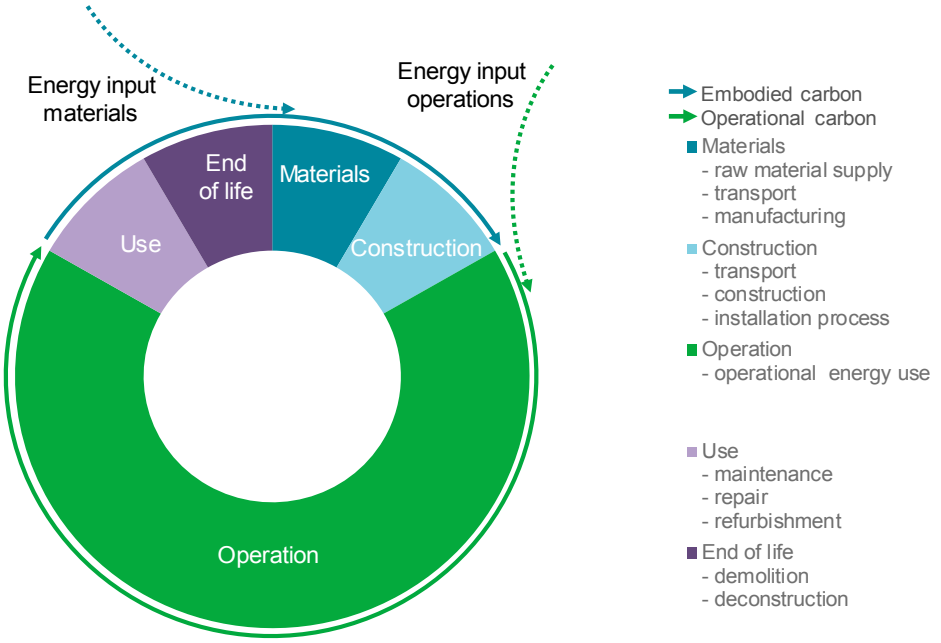
Over its lifetime, a building's carbon footprint consists of the embodied carbon from the manufacture and processing of building materials and construction, as well as the operational carbon from the energy use of its operations. **Whole-life carbon** is described as **operational carbon + embodied carbon,** as calculated over the whole life cycle of the building (Figure 4).

The terms "net-zero energy" and "net-zero carbon" emission buildings do not have widely recognised standard definitions, and they can be applied to different scopes and site boundaries; however, this roadmap utilises the following definitions, based on those described in *Zero Energy Building Definitions and Policy Activity – an International Review* (OECD/IPEEC, 2018):

- **Net-zero operational energy** buildings are buildings whose energy consumption over the course of the year is offset by renewable energy generation. Depending on the definition boundary, the renewable energy generated can be on-site or off-site.
- **Net-zero operational carbon buildings** are buildings whose carbon emissions resulting from electricity consumption and any other fuels consumed on-site are offset through renewable energy generation or other forms of carbon offsetting. Again, the offset may occur on-site or off-site.
- **Whole-life net-zero carbon emission** buildings are therefore buildings whose carbon emissions from the materials used in their construction, or embodied carbon, are offset, as well as its operational carbon emissions.
- **Note**: These definitions of net-zero imply a strong effort to increase efficiency first. In the event that renewable energy is not available or feasible, the term "**near-zero**" or "**net-zero ready**" can also be used to reflect the fact that the building itself has done what it can to get as close to zero energy demand.

These definitions can be applied to the building level as well as to the neighbourhood, district or city level, i.e. achieving net-zero carbon neighbourhoods, districts or cities.

Figure 4 • Whole-life carbon: Definitions, adapted from European standard EN 15978



The electricity sector will have a crucial role in reaching a net-zero carbon buildings sector, with particular challenges in each region given the fuels used to generate electricity. Indeed, the decarbonisation of the electricity sector will represent over 30% of the emissions reductions needed to reach the SDS pathway (IEA, 2019a).

Finally, to reach the ultimate goal of whole-life net-zero carbon in buildings, the embodied carbon of building materials should be reduced and offset through low-carbon materials, more efficient manufacturing techniques and the optimisation of materials usage. Indeed, material efficiency strategies can reduce the whole life-cycle emissions of residential buildings by up to 35-40% in Group of Seven (G7) countries[3] (IRP, 2020). Increased data collection, labelling, the development of new construction techniques and disclosure of building performance will be essential tools for enabling this transformation at scale, in all regions.

All eight activities described in this roadmap have an essential part to play in decarbonising buildings across their life cycle.

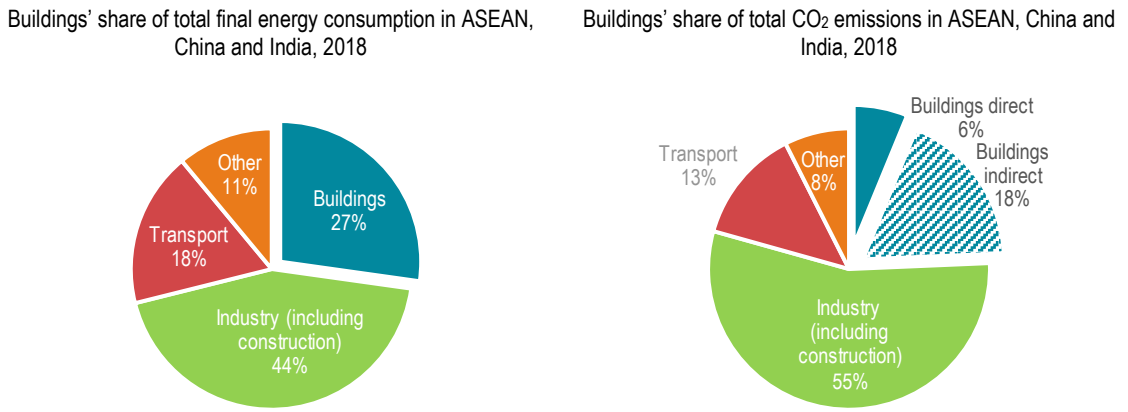
[3] Estimate for G7 countries.

Asia overview

Energy and emissions

In 2018, energy consumption in buildings accounted for 27% of total final energy consumption in ASEAN, China and India,[4] and 24% total process and energy-related CO_2 emissions, or 3.2 gigatonnes of CO_2 ($GtCO_2$) (Figure 5) (IEA, 2019a). When also accounting for the production of construction materials, which accounts for approximately 11% of emissions globally (GlobalABC/IEA/UNEP, 2019), buildings and construction stands out as critical to address climate change.

Figure 5 • Share of buildings final energy and emissions in ASEAN, China and India, 2018



Notes: "buildings" energy use and emissions refers to the operational energy consumption, and does not include the construction phase or the energy and emissions associated with the manufacture of materials. Direct emissions include those from coal, oil, natural gas and biomass. Indirect emissions are the emissions from power generation for electricity.

Source: Adapted from IEA (2019a), *World Energy Outlook 2019*.

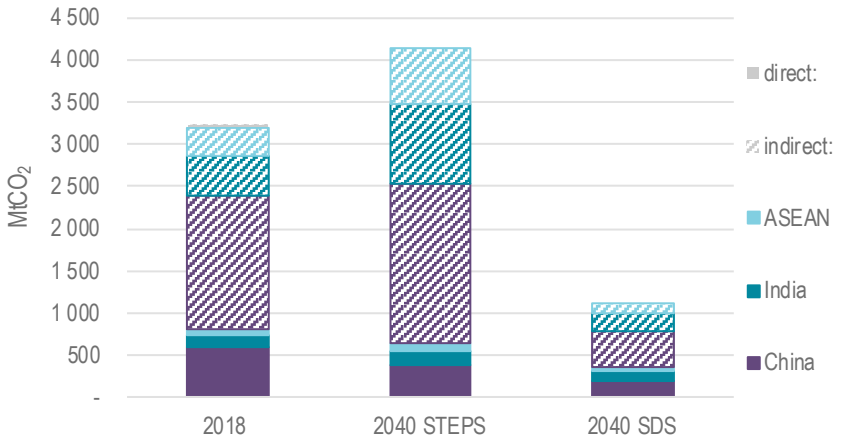
Opportunities exist for significant reductions in energy and emissions in the buildings and construction sector, as well as supporting universal access to electricity and clean cooking. These opportunities are illustrated in the IEA SDS.[5] In the SDS, global CO_2 emissions fall from 33 billion tonnes in 2018 to less than 10 billion tonnes by 2050 and are on track to net-zero emissions by 2070.

As shown in Figure 6, in the SDS, emissions from buildings in ASEAN, China and India in 2040 could be 3 $GtCO_2$ per year lower than they are on track to be in the STEPS,[6] while supporting growth in GDP per capita of over 200% and an increase in floor area of about two-thirds. In fact, annual emissions from buildings could even be 2 $GtCO_2$ lower than they are today. Emissions of 2 $GtCO_2$ per year is equivalent to the emissions from almost 500 coal-fired power plants.[7]

These savings from buildings would contribute to one-third of the total emissions reductions required to get on track with the SDS.

[4] Due to the grouping of countries within Asia for which disagreggated data are available, the data shown include the ten ASEAN member countries, China and India.
[5] The SDS holds the temperature rise to below 1.8 °C with a 66% probability without reliance on global net-negative CO_2 emissions; this is equivalent to limiting the temperature rise to 1.65 °C with a 50% probability.
[6] The STEPS aims to reflect the outcome of all current policies as well as policies that have been announced in targets and plans.
[7] www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.

Figure 6 • Emissions from buildings in ASEAN, China and India 2018 and in 2040 under the IEA STEPS and SDS

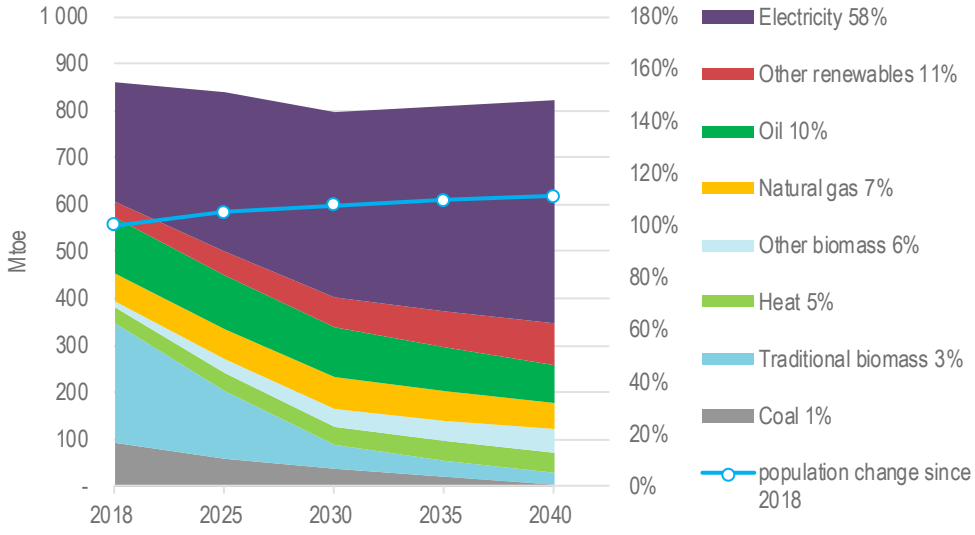


Notes: "buildings" energy use and emissions refers to the operational energy consumption, and does not include the construction phase or the energy and emissions associated with the manufacture of materials. Direct emissions include those from coal, oil, natural gas, and biomass. Indirect emissions are the emissions from the power generation for electricity.

Source: Adapted from IEA (2019a), *World Energy Outlook 2019*.

The SDS also shows that improved efficiency in the consumption of coal, natural gas and oil could deliver 450 $MtCO_2$ annual reductions in direct emissions from 2018. Decarbonisation of the grid and more electrical energy efficiency could deliver a further 1 600 $MtCO_2$ of indirect annual emissions reductions while ensuring universal access to energy and clean cooking, and continued trends such as increased floor area and ownership of appliances.

Figure 7 • Final energy consumption in buildings in ASEAN, China and India to 2040 in the SDS, and % share in 2040



Note: Mtoe = million tonnes of oil equivalent.

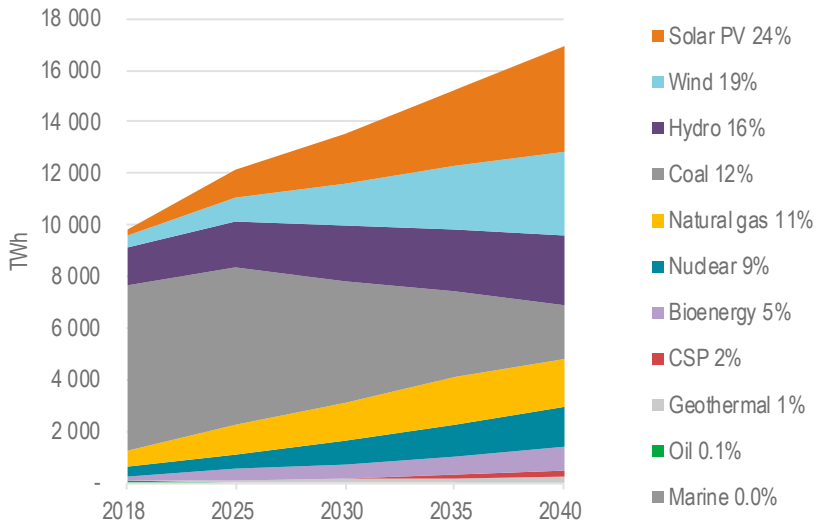
Source: Adapted from IEA (2019), *World Energy Outlook 2019* and IEA (2017), *Energy Technology Perspectives 2017*.

The energy consumption in buildings in 2018 is dominated by electricity (30%) and traditional biomass. As shown above in Figure 7, electricity is expected to grow to 58% or 478 Mtoe by 2040 under the SDS, while traditional biomass is almost phased out as access to clean cooking grows.

Under the SDS, with energy efficiency, the final consumption of energy in buildings decreases by 2% while serving an additional two-thirds of floor area, increased population, ownership and use of electrical appliances.

Energy intensity will have to improve by 2% per year to 2030 in China, 4.2% in Southeast Asia and 5.5% in India to reach reductions in energy intensity in energy per square metre of 18% in China, 23% in Southeast Asia and 43% in India as compared with building energy intensity in 2018 (IEA, 2019a) .

Figure 8 • The evolution of the electricity generation mix in ASEAN, China and India to 2040 in the SDS, and % share in 2040



Notes: TWh = terawatt-hours; CSP = concentrated solar power.

Source: Adapted from IEA (2019a), *World Energy Outlook 2019*.

As illustrated above in Figure 8, electricity from the grid in ASEAN, China and India in 2018 is largely generated through coal, almost half of which is in China, with coal generation accounting for almost 70% of total generation in China, 74% in India, and 40% in ASEAN.

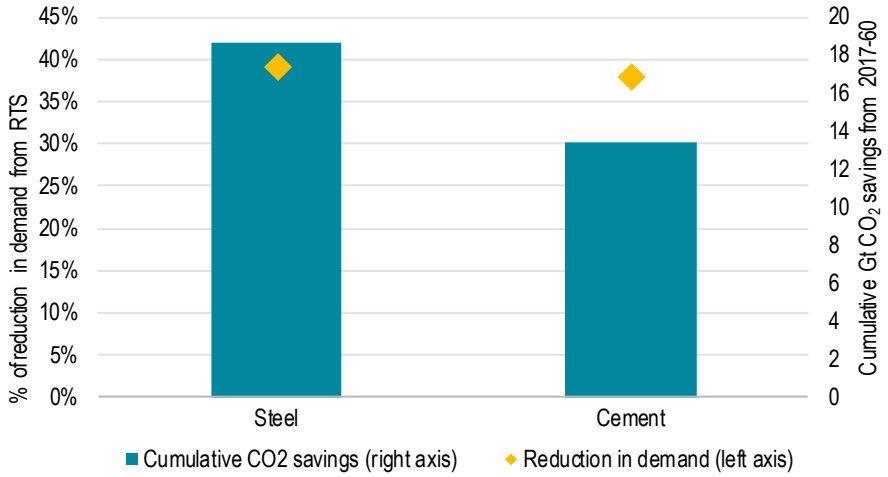
Driven by strong efficiency and decarbonisation policies, the SDS suggests that by 2040, coal dependency could drop to 12%, or 2 100 TWh. Solar PV, wind, bioenergy and nuclear would grow significantly, resulting in a grid that is almost 70% renewable.

Generation of solar PV grows to over 4 100 TWh and wind to over 3 260 TWh in the SDS.

The buildings and construction sector, with its demand for building materials and building appliances, is one of the most resource-intensive global value chains and is both a challenge and an opportunity for the region to address carbon emissions. In Asia, there is a lack of data on the potential for emissions reductions from material efficiency at a regional or national level. However, at a global level, with greater material efficiency in design and construction, the demand for steel and cement in buildings in 2060 could be almost 40% lower than in a Reference Scenario (IEA, 2019c) (Figure 9). These reductions could be achieved through optimising building frames

and structures, extending the lifetime of buildings, and using best available steel and cement. These are two of the main components of buildings and major sources of CO_2 emissions.

Figure 9 • Possible reductions in material demand and CO_2 emissions reductions in buildings under the Material Efficiency Scenario compared with the Reference Technology Scenario by 2060 (global)



Source: Adapted from IEA (2019c), *Material Efficiency in Clean Energy Transitions*.

In the context of Asia, there are two main trends to note. China, which has seen an unprecedented urbanisation rate, has now reached a state where material demand will be decreasing. Cement and steel production is expected to decrease 40% by mid-century (Energy Transitions Commission, 2018). With coal as one of its main energy sources, transitioning towards a cleaner energy mix will be a key issue. China will also be able to play a major role through reinforced policies and initiatives as part of the Belt and Road Initiative framework in order to promote low-carbon materials.

On the other hand, in most of the ASEAN region and especially in India, urbanisation is projected to continue to grow substantially. As a result, cement production is expected to more than triple by mid-century, and steel stock per capita in India and the ASEAN region is at only 1 tonne, compared with developed countries, where it rises to between 10 tonnes and 14 tonnes per capita (Pauliuk, Wang, & Muller, 2013). Elsewhere across the region, population and wealth increases will continue to add pressure around demand for resources and materials. These trends present a unique opportunity to maximise the potential of the benefits from adequate and innovative policies, not only in terms of material demand and construction techniques, but also in production methods.

Regional context: Asia

This section aims to provide some key information on the region to describe the context in which the buildings and construction sector policies are embedded.

Macroeconomic and demographic

With 4.5 billion people, the Asia Pacific region is home to 60% of the world's population and is responsible for almost half of global GDP (IMF, 2019). With the strong growth from the emerging economies of China, India and Southeast Asia, the region has consistently outpaced global GDP growth and showed 4.8% growth in 2018 (IMF, 2019).

The population across Asia will continue to grow, in particular in South Asia, with India's population expected to overtake China's by 2030 (UN DESA, 2019). Indeed, due to consistent economic and population growth, China and India will represent the largest increase in energy demand to 2040 (IEA, 2019a). These trends, together with increased urbanisation, poverty alleviation and a growing middle class, are leading to greater demand for buildings and access to more services and comfort.

The economies in Asia are embedded in the global economic value chain in different ways, which impacts their exposure to policies in other countries and regions (appliance manufacturers such as China) as well as vulnerability to economic fluctuations and depleting natural resource stocks (Southeast Asia for timber and minerals).

Priorities

The region remains heavily reliant on fossil fuels, especially coal for power generation and oil for transport, which poses a risk to energy security. This also affects global energy markets – China's restructuring of energy supply and reduction of reliance on coal by moving to gas has caused a surge in the regional liquefied natural gas demand (IEA, 2019d). Similarly, Southeast Asia, which has historically been a net energy exporting region, had a fossil fuel trade deficit of USD 57 billion in 2018 (IEA, 2019e). The region's energy mix has also contributed to local air pollution issues, and addressing these has become a national priority especially in China, India and Thailand.

Currently, Asia has relatively low GHG emissions per capita, at 3.8 tonnes of CO_2 per capita (tCO_2/capita) compared with 16.4 tCO_2/capita in North America and 6.4 tCO_2/capita in Europe (The World Bank, 2014a). However, emissions per capita continue to rise and the size of the region makes it one of the highest-emitting regions in the world in absolute terms. At the same time, the majority of countries with the highest climate risk exposure are also located in Asia. This includes Bangladesh, India, Myanmar, Nepal, Pakistan, the Philippines, Thailand and Viet Nam, among others (Eckstein, Hutfils and Winges, 2019).

Asia is also facing increasing pressure in its urban areas due to its continuously growing urban population and existing structures of informal settlement,[8] which pose a challenge in implementing building standards effectively.

Investment environment

Investing in zero-emission, efficient and resilient buildings is a cost-effective way to reduce carbon emissions, improve air quality and contribute to productivity (IEA, 2019f; IFC, 2016). A significant scale-up in investment will be needed to unlock these potential benefits. According to an IFC

[8] Informal settlement as percentage of urban population varies between 25% (China and India) and 45% to 55% for countries such as Cambodia Bangladesh and Pakistan (The World Bank, 2014b).

study, the investment opportunities in green buildings is estimated at USD 17.8 trillion in East Asia Pacific and South Asia, representing over 70% of the global total (IFC, 2019).

Yet, despite these numerous benefits, the investment potential remains largely untapped. Many economies, especially in developing Asia, are prioritising other policy issues such as energy access and have fossil subsidies in place. In South Asia and Southeast Asia, for instance, these subsidies distort the market for low-carbon investment decisions. Moreover, the region is facing rising debt levels that are leading to tighter lending conditions. This makes access to finance by small and medium-sized enterprises and individual households more difficult. Nevertheless, inflation rates in Asia have been constant in recent years, averaging around 3% across the region (ranging from 1.9% in East Asia to 3.9% in South Asia), creating a stable credit environment (IMF, 2019).

An enabling policy framework for investment and finance is thus critical to mobilise and effectively channel finance to investments to the low-carbon buildings and construction sector. This includes support for low-carbon technologies, removing fossil fuel subsidies, building capacity among policy makers and financial institutions, and establishing effective retail channels. Each section in this roadmap provides an overview of tools that can be used to stimulate finance.

Policy

Despite these urgently needed ambitious actions, according the GlobalABC's *A Guide for Incorporating Buildings Actions in NDCs* (UNEP, 2018) most NDCs do not include much on building decarbonisation strategies. Many countries in Asia mention buildings in some form in their NDCs. While the NDCs appear to be reinforced through a strong foundation of regulation in the big economies of China and India, the majority of emerging and developing Asia do not include concrete, ambitious and measurable buildings and construction sector actions (GlobalABC/IEA/UNEP, 2019). Indeed, according to the 2019 *Emissions Gap Report*, many national and subnational governments are yet to adopt legally binding ambitious targets in the buildings sectors, among others (UNEP, 2019).

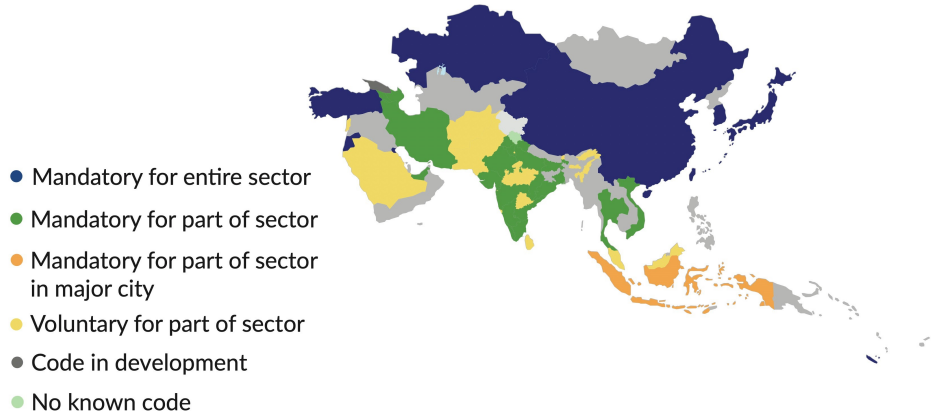
As to building policies, the policy environment and priorities vary greatly across the region. Most countries in the region have high-level strategies and targets in place for building energy efficiency, including the Southeast Asian economies, India and China, but there is room to further address building decarbonisation. While some countries already have a suite of policies in place to enable the development of low-carbon buildings (i.e. China, Japan and Singapore), others are focusing their efforts and resources on energy access (e.g. Indonesia, Viet Nam). Developed Asia, as well as the emerging economies of India and China, have had building codes and standards in place for over 10 to 20 years, which are complemented through subsidy schemes and other incentive mechanisms. At the regional level, there are ongoing efforts in regional harmonisation of MEPS for appliances and equipment, which could further enable energy efficiency improvements across the region.

The maps in Figures 10, 11 and 12 show the status of different jurisdictions for three different buildings policies, as of 2019 (GlobalABC/IEA/UNEP, 2019):

Building codes

Building energy codes, or standards, are requirements set by a jurisdiction (national or subnational) that focus on reducing the amount of energy used for a specific end use or building component. In 2019, 44% of countries in Central, South, East and Southeast Asia had mandatory or voluntary building energy codes (Figure 10).

Figure 10 • Building energy codes by jurisdiction, 2017-18



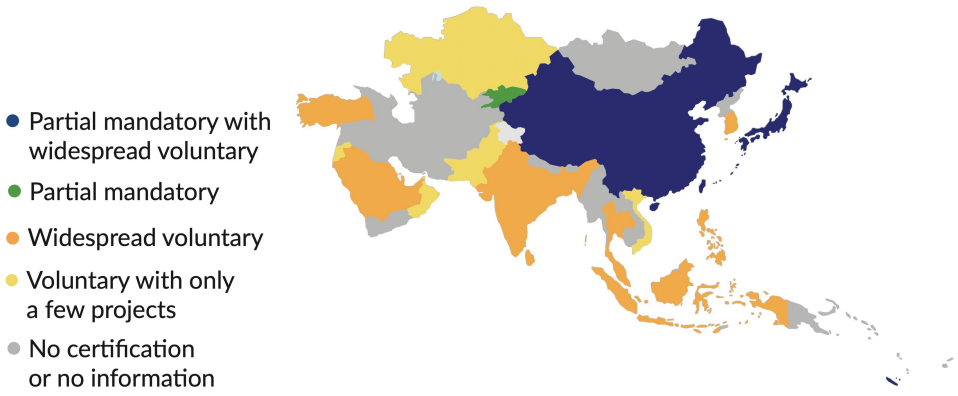
Note: This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city or area.

Source: GlobalABC/IEA/UNEP (2019), *2019 Global Status Report for Buildings and Construction: Towards a Zero-Emission, Efficient and Resilient Buildings and Construction Sector.*

Building certification

Building energy certification involves programmes and policies that evaluate the performance of a building and its energy service systems. Certification may focus on rating a building's operational or expected (notional) energy use, and can be voluntary or mandatory for all or part of a particular buildings sector. As of 2018, 48% of countries in Central, South, East and Southeast Asia had adopted building energy performance certification programmes, with almost 40% of them with mandatory or widespread certification programmes (Figure 11).

Figure 11 • Building energy certification programmes by jurisdiction, 2017-18



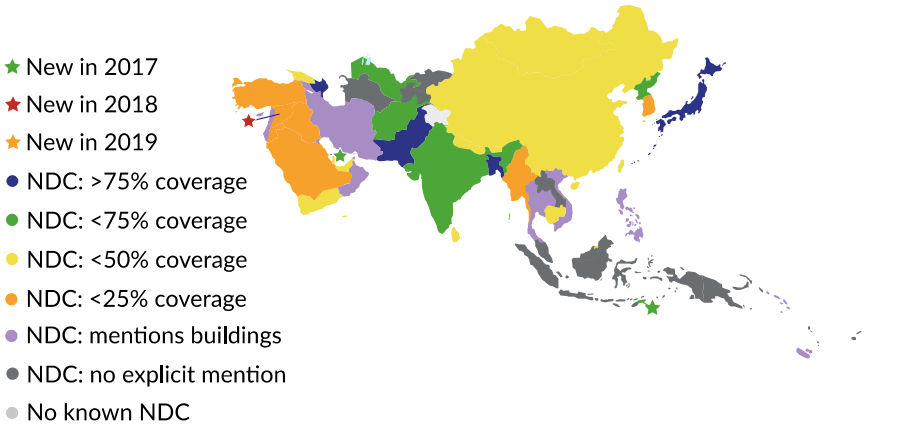
Note : This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city or area.

Source: GlobalABC/IEA/UNEP (2019), *2019 Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector.*

NDCs

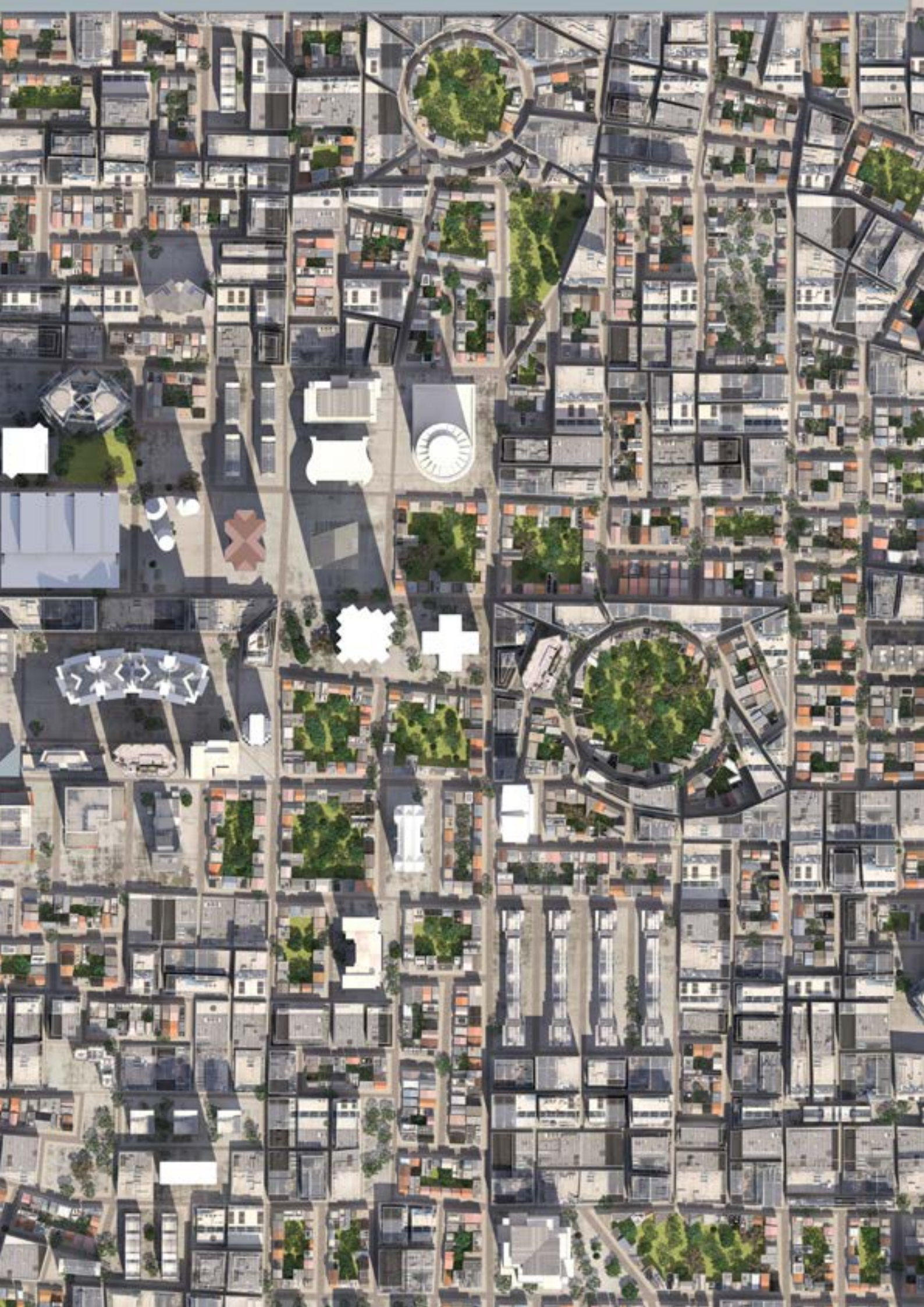
Almost all countries within Asia have reported an NDC, which is the process by which countries announce their national-level commitments to reduce carbon emissions. To date, most Asian countries (72% of those in Central, South, East and Southeast Asia) mention buildings, although most NDCs still do not include explicit actions to address buildings sector energy use and emissions (Figure 12). This roadmap aims to support governments in their NDC development by providing an illustration of the pathway towards a zero-emission, efficient and resilient building stock.

Figure 12 • Building sector emissions coverage in NDCs by jurisdiction, 2017-18



Note: This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city or area.

Source: GlobalABC/IEA/UNEP (2019), *2019 Global Status Report for Buildings and Construction: Towards a Zero-Emission, Efficient and Resilient Buildings and Construction Sector.*



Targets and timelines

Activity 1: Urban planning

Urban planning can be defined as "the planning, design and regulation of the uses of space that focus on the physical form, economic functions, and social impacts of the urban environment and on the location of different activities within it" (Fainstein, n.d.). Sustainable urban planning frames the supply and demand for urban energy with a view to: 1) protecting the environment (including mitigating climate change, reducing air pollution and limiting resource depletion); 2) achieving economic and human development goals; and 3) improving the resilience of local communities and urban energy infrastructure to disasters (IEA, 2016).

In the wake of the COP21 and the Climate Summit for Local Leaders in November 2015, and the Habitat III United Nations Conference on Housing and Sustainable Urban Development, which took place in Quito in October 2016, cities are becoming increasingly central to the transition towards sustainable energy systems. Greater alignment among governance structures, both between national and local policies (vertical integration) and between local sectoral institutions (horizontal integration), plays an essential role in meeting environmental, economic and social objectives simultaneously (IEA, 2016). Read more about institutional coordination and multiple stakeholder engagement in the section Roadmap support: Enablers.

The New Urban Agenda, adopted at the Habitat III conference in October 2016, lays out a 20-year collective vision to achieve sustainable cities, in line with SDG 11, and elevates the role of cities in addressing climate change and in disaster risk management. It promotes compact cities, polycentric urban growth, transit-oriented development, sprawl containment and vibrant public spaces.

At the urban scale, the siting of buildings has both direct and indirect impacts on energy use. Urban form is an important determinant of urban energy demand, encompassing the overall physical characteristics of the built environment, such as shape, size, density and configuration, the street network, and public spaces. Likewise, at the building scale, compactness, height, orientation and mutual shading have a great influence on energy demand in buildings and on local renewable energy potential. As buildings are typically governed by rules set in urban planning regulations, their impact on energy consumption and potential for local energy production should be taken into consideration when defining urban planning and land-use policies and deciding on development projects.

In the coming decades, with increasing linkages between urban planning and its impact on energy use and emissions from buildings and transport, urban planning policies can play a significant role in embedding energy efficiency in spatial planning to support the transition towards zero-emission, efficient and resilient urban form, buildings and construction.

Box 1 • Urban planning in Asia: Trends and challenges

The Asia region has the largest urban population, with the Asia Pacific region home to many of the largest cities on earth. In 2014, Asia accounted for 16 of the 28 megacities (with more than 10 million inhabitants) of the world and 28 of the 44 large cities (with 5 million to 10 million inhabitants). In the list of the world's ten most populous cities, the majority are in Asia, including Tokyo, Delhi, Shanghai, Dhaka, Mumbai, Beijing and Osaka. With urban growth comes the need to expand the infrastructure in the region. Services need to be designed taking into consideration the future requirements and sustainability.

According to the Asian Development Bank (ADB), the number of people living in cities located in coastal areas and flood plains in Asia is projected to more than double between 2000 and 2060 (ADB, 2017). As cities grow, impermeable surfaces (asphalt and concrete) such as roads and pavement expand and exacerbate flood risk by covering land that could absorb water. Changing climate patterns have also affected some cities adversely with

frequent storms leading to floods. Hence storm-water management is an important aspect to be considered in Asian cities together with sewage, sanitation and solid waste management.

The increasing share of artificial surfaces, combined with rising population density, increasing transportation activity and the growing use of air conditioners for space cooling, all lead to an increase in ambient waste heat in urban areas, often referred to as the urban heat island (UHI) effect. Kataoka analysed the long-term trends in surface temperature in several large Asian cities (including Bangkok, Jakarta, Manila, Osaka, Seoul, and Tokyo) and found an increase of UHI intensity by 0.6°C to 2°C during the 20th century, whereas the global mean temperature increased by only 0.7°C over the same period (Kataoka & al, 2009). These trends point to the importance of energy-efficient cooling in the region, which is a focus of recent IEA analyses (IEA, 2019e).

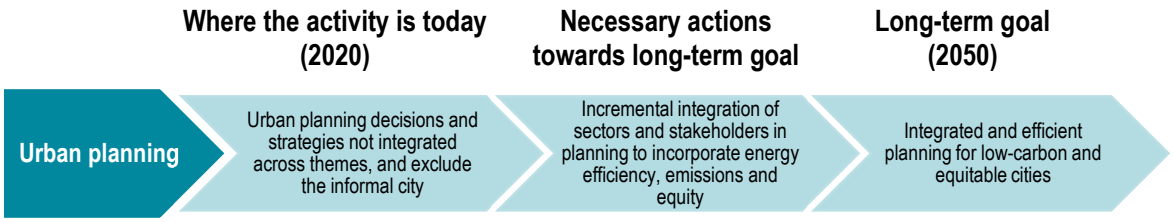
A general trend towards the reduction of poverty is observable across Asia, and in particular in Southeast Asian cities. Overall, the share of urban population living under the poverty line has substantially decreased in the sub region: it fell from 19.4% to 8.3% in Indonesia between 1999 and 2014, from 22.3% to 9% in Thailand between 2000 and 2012, and from 35.2% to 12% in Viet Nam from 2002 to 2013 (OECD, 2016).

The share of the population living in slums in Southeast Asia decreased from 50% in 1990 to 31% in 2010, and the absolute number of urban dwellers living in slums has remained steady or slightly increased in cities of the region, due to population growth (OECD, 2016). The United Nations system defines slums as characterised by the absence of basic services, such as improved drinking water and adequate sanitation, along with insecure tenure, non-durable housing and overcrowding. The transition towards zero-emission, efficient and resilient urban form, buildings and construction can therefore yield multiple positive benefits such as improved living standards and better access to basic services for poor urban populations.

While many Asian countries have existing policies to drive low-energy and low-carbon buildings, few urban planning policies explicitly integrate buildings with other dimensions and services. Local authorities can play an important role in combining the economic goals of cities with social and environment goals.

Key actions for urban planning

Figure 13 • Key actions for urban planning in Asia



Key actions for urban planning in Asia include:

- **Integrated urban planning policies**. Enact urban planning policies that take into account the long-term goal of decarbonising the buildings and construction sector. Urban planning policies should incrementally increase in scope to include not only the formal city but also the informal city[9]. Involve citizens and favour their active participation in the planning process so as to improve their understanding of urban issues and foster the sharing of knowledge.
- **District energy planning**. Enable a systemic approach through integrated planning of both energy demand and supply at the district level to deliver more efficient and low-carbon solutions, in line with the "energy efficiency first" principle. Focus on linking new high-density development into new district heating and cooling systems and increasing supply options in existing dense urban environments.
- **Institutional co-ordination**. Ensure collaboration among national, subnational and city levels, and across sectors including transport, spatial planning, energy supply, social housing and housing.
- **Transport and transit-oriented design**: Encourage urban growth that prioritises compact urban form and mixed land use in combination with public transport infrastructure and walkability.

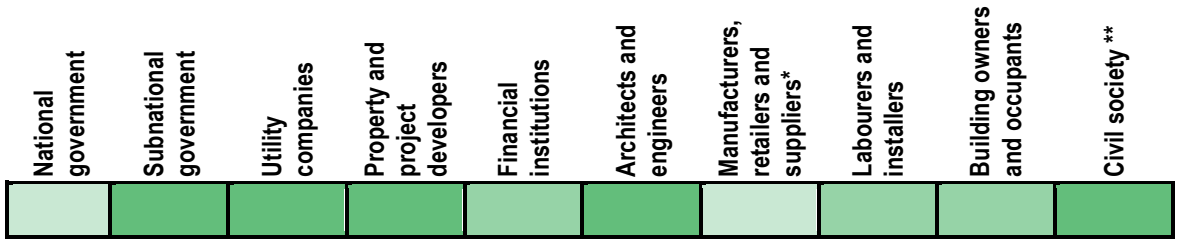
[9] Note: Informal cities are defined as areas where groups of housing units have been constructed on land that the occupants have no legal claim to, or occupy illegally.. Those areas often lack utilities and services, e.g. clean water supply and sanitation (Within Formal Cities, 2014).

Stakeholders for urban planning

By nature, robust municipal plans need to draw in all key stakeholders, so they come to understand different urban pressures and priorities and foster agreement on the acceptable trade-offs. In Asia, the key stakeholders for sustainable urban planning include those that can influence urban planning and those that can deliver the results of zero-emission, efficient and resilient buildings through urban planning. Additional stakeholders include those that can support the process through research, funding, training and making technologies available.

These stakeholders are mapped in Table 2, where the darker the colour, the higher the impact that stakeholder group has on the activity and the more essential it is to delivering the roadmap targets

Table 2 • Stakeholder mapping for urban planning in Asia



* of appliances and materials

** including academia, non-governmental organisations (NGOs), research institutions, social networks and community associations.

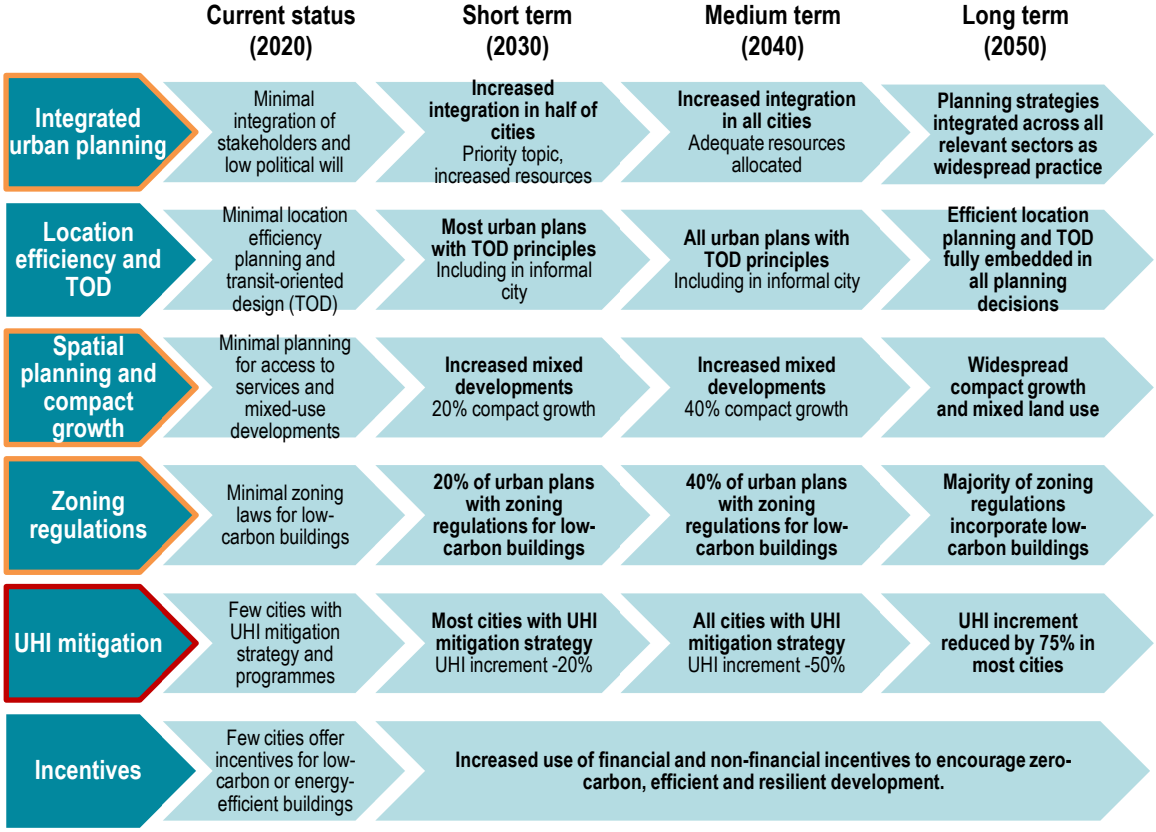
How to read: The darker the colour, the higher the impact that stakeholder group has on the activity and the more essential it is to delivering the roadmap targets.

Policy for urban planning

Urban planning policy can support goals for zero-emission, efficient and resilient buildings by enabling a local environment where designers, developers and owners have the support to invest in the broader sustainable development goals.

The sub-targets and timelines in Figure 14 offer more details:

Figure 14 • Policy timelines for urban planning in Asia



Notes: The **proposed regional target** is in **bold**. Below that is the proposed accelerated target. A red border indicates an ambition gap for that target (more details below); an orange border indicates a gap in data or consensus (more details below).

Details on the policy targets for urban planning are outlined below. For each item, in *italic* is a description of the consensus among the consulted local building experts regarding the evolution of the item between now and 2050. Where there was a significant gap between what was expected to be achievable by 2030, 2040 and 2050, the item is highlighted with a **red mark**, denoting that it is an area that will require particular action in its implementation. Where there was insufficient information, or insufficient agreement among responses, the item is highlighted with an **orange mark**, denoting that it is an area that requires additional information and consultation.

- **[data gap] Integrated urban planning**: Integrated urban planning creates a formal framework to encompass multidisciplinary issues, such as climate change, disaster risk reduction and emergency response, as well as land use and transport, location of services and infrastructure, social housing, and digital and open data information frameworks. A critical aspect of delivering this planning framework is the articulation of a clear city vision, developed in collaboration with citizens to reflect their needs. Institutional co-ordination can start with the ministries in charge of land use, transportation, buildings, and energy

and environment, and progressively integrate more sectors as priority areas are defined (e.g. health, education, water and sanitation, waste, public parks). The development of a shared and integrated city vision requires alignment among different levels of government and across the motivations of different stakeholders. Integrated planning is therefore underpinned by active and ongoing processes of communication and co-ordination among stakeholders at all stages of planning. UN-HABITAT's statistics show that of the 862 million people living in informal settlements worldwide, over 60% of them live in Asia (including West Asia). The proportion of urban population living in informal settlements in Asia is almost 30%, and has been increasing (ADB, 2013). Furthermore, Southern and Southeast Asia have high shares of informal employment, of over 80% of the population (International Labour Organization, 2018). As well as integrated, urban planning strategies should be incremental. Incremental urban planning is based on the recognition that upgrading and incorporating informal settlements into the formal fabric is a key vision for shaping a wealthier and more resilient Asian urban landscape and should be seen as part of the integrated development strategy.

- **Location efficiency and TOD**: There is growing consensus on the importance of strategically integrating urban infrastructure and land-use planning to achieve zero-carbon emissions, efficiency and resilience goals. Urban form is a key determinant of travel needs and behaviour. Housing location decisions have a huge impact on overall energy use and emissions. Households can reduce their transportation-related energy use by opting for compact, mixed-use communities that are "location efficient", i.e. accessible through multiple modes of active and public transportation (EPA, 2011). The majority of location efficiency strategies are controlled by local government authorities. Zoning regulations that support location efficiency promote mixed-use zones, adjust zoning standards to allow compact urban development, raise the threshold of building density in urban cores and around transit nodes that can support denser development, encourage walkable communities, and designate strategic growth areas to direct urban expansion and property development (IRP, 2018). Zoning mechanisms to promote location efficiency include the use of overlays that add transit-related and density requirements to existing codes (ACEEE, 2019). *Stakeholder feedback: There was consensus that transit accessibility could be fully incorporated into urban plans between 2040 and 2050.*

- [data gap] **Spatial planning and compact growth**: Planners, developers and designers can work together to increase the mixed-use nature of compact urban districts that provide easy access from residential areas to transit, retail, employment and entertainment to limit energy use and emissions from transport that could be avoided, and to enhance quality of life. Compact urban configurations can improve living conditions of urban residents through: spatial restructuring of the urban form to achieve "strategic intensification" (IRP, 2018); human-scale design that creates socially mixed neighbourhoods, with a diverse mix of housing types and social functions, and strengthens access to employment opportunities near residential areas; as well as sustainable mobility options such as light rail and bus rapid transit (BRT) systems, bike lanes and overall walkability (IRP, 2018). Additional aspects can also be integrated into sustainable spatial planning, such as electric distribution networks and, air corridors to channel flow of air at the urban level, among others. *Stakeholder feedback: The lack of any spatial planning strategy was cited by several respondents.*

- [ambition gap] **Zoning regulations**: Local jurisdictions have an important role to play in integrating energy-related requirements into zoning regulations and streamlined "form-based" codes that increasingly link urban planning to sustainable buildings and communities not only in terms of controls on density and land use, but also in terms of the

physical form of the built environment. The objective is to create a specific type of urban fabric, which promotes energy-resilient, low-resource, compact, walkable and community-driven neighbourhoods. For example, form-based codes can promote shared parking, integrated storm-water runoff solutions, quiet and clean spaces to allow for natural ventilation strategies to be used, or shared solar PV rooftop installations. These approaches can promote efficient systems by maximising synergies between highly efficient buildings and renewable energy sources and demand response. This initially could include special zoning districts that require increased sustainability and expand over time to include all zoning districts. *Stakeholder feedback: There was very little consensus from local stakeholders as to the extent to which zoning regulations would be implemented for low-energy or low-carbon buildings, with some saying that "all" municipalities could implement zoning regulations by 2050, but many others citing "few" or "don't know". A common factor for success cited was political will.*

- **[ambition gap] UHI mitigation**: Un-vegetated, impermeable and dark surfaces in cities tend to generate UHI effects, i.e. higher ambient temperatures. Buildings, parking lots, and paved surfaces absorb more heat than moist vegetated surfaces, which release water vapour and provide shade to cool the surrounding air. Consequently, the annual mean air temperature of a large city can be up to 3 °C warmer or more than surrounding rural areas (EPA, 2019). These temperature increases will add to the warming that cities are experiencing from climate change. To minimise this effect and mitigate extreme heat events, cities are establishing goals for UHI reduction and implementing a variety of programmes and policies. Local authorities may aim to reduce impermeable surface areas, increase the tree canopy, deploy cool or green roofs and facades, or expand wetlands. Quantitative goals should be included in formal city plans and specify a future target date or annual commitment (ACEEE, 2019). *Stakeholder feedback: Strategies for mitigating the UHI effect in cities is at present largely absent from urban planning strategies, and there was strong consensus that this would be implemented only by 2040 and in some cases, 2050.*

- **Incentives**: Financial and non-financial incentives such as tax rebates, density bonuses, expedited permitting or increased project scope can be used by cities to encourage development that is in line with the aim of reaching zero-carbon, efficient and resilient buildings and cities. *Stakeholder feedback: There was consensus that the use of incentives is currently very limited across the region, while acknowledging that these important tools would increase to be widespread by 2050.*

Box 2 • Regional examples of policy action for urban planning

TOD in Asian cities

According to the ADB, Asian cities add about 44 million inhabitants every year. Road congestion already costs Asian economies an estimated 2-5% of GDP every year due to time loss and higher transport costs. The region's cities suffer from the highest air pollution levels in the world, with as much as 80% attributable to transport. Consequently, many cities are investing heavily in mass public transit systems while embracing TOD principles. Key factors underpinning the successful implementation of TOD in Asian cities include: "a shift from highway-based zoning to transit-oriented zoning […] a balance between public benefit and private benefit; the connection of transit services and affordable housing; and multi-modal connection planning, including walking", Kidokoro (2019).

Many metropolitan cities in Asia face the twin challenges of local air pollution and road congestion, in addition to car traffic saturation.

Cebu BRT system

The city of Cebu, the second-largest urban area in the Philippines, is faced with increasing congestion, a rise in the number of road accidents, local air pollution, growing fossil fuel consumption for road transport, and rising GHG emissions. The BRT project, with funding from the French Development Agency (AFD), aims to provide the city with an efficient, safe and affordable public transport system, by optimising bus service on dedicated or priority lanes, along a 23 kilometre-long corridor. The BRT is expected to result in 80 000 tonnes of CO_2 equivalent (tCO_2-eq) to 185 000 tCO_2-eq a year in emissions reductions, and related improvement in local air quality, significant improvement in public transit providing better access to employment and services for an estimated 330 000 passengers a day, and a reduction in the number of road accidents.

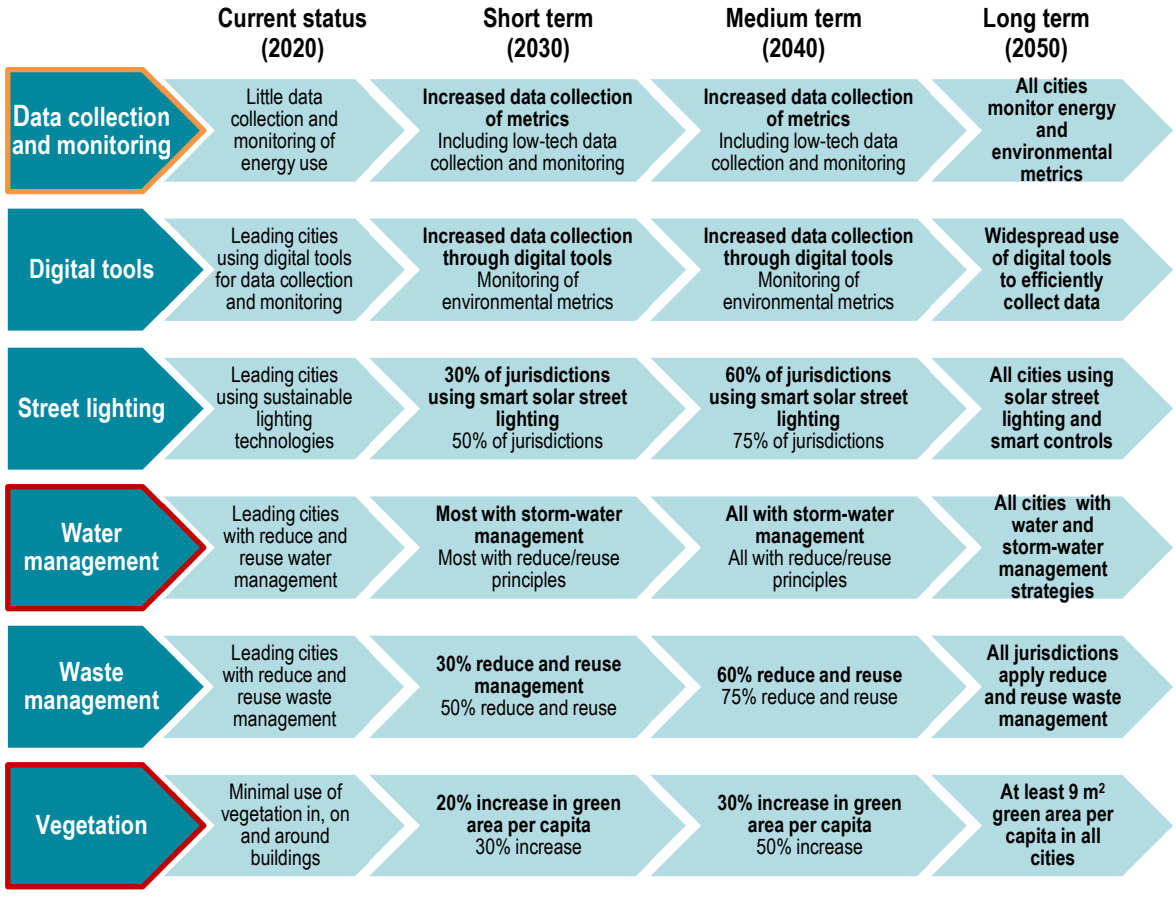
The Asia-Pacific Economic Cooperation Low-Carbon Model Town

The Asia-Pacific Economic Cooperation (APEC) Low-Carbon Model Town (LCMT) project launched in 2010 forms part of APEC's Energy Smart Communities Initiative. The project aims to encourage the creation of low-carbon communities in urban development planning and share best practices to formulate appropriate combinations of low-carbon measures while taking into account socio-economic conditions and city-specific considerations. The LCMT project consists of two main activities: 1) the development of the Concept of the Low-Carbon Town in the APEC Region; and 2) the Feasibility Study and Policy Review of planned development projects as examples of real-life applications of the concept. The low-carbon town development strategies include two essential dimensions: 1) quantitative low-carbon reduction targets with a time frame; and 2) selection of the most appropriate set of low-carbon measures. As of 2018, the LCMT project conducted policy reviews of the following seven cities: Krasnoyarsk City, Russia; Mandaue, Cebu, The Philippines; Bitung, North Sulawesi, Indonesia; San Borja, Lima, Peru; Da Nang, Viet Nam; Koh Samui, Thailand; and Yujiapu Central Business District, Tianjin, China.

Technology for urban planning

Technology can enable increased action towards zero-emission, efficient and resilient buildings when coupled with urban planning. Specific targets and timelines for sustainable urban planning technologies are outlined in Figure 15:

Figure 15 • Technology timelines for urban planning in Asia



Notes: The **proposed regional target** is in **bold**. Below that is the proposed accelerated target. A red border indicates an ambition gap for that target (more details below); an orange border indicates a gap in data or consensus (more details below).

Details on the technology targets for urban planning are outlined below. For each item, in *italic* is a description of the consensus among the consulted local building experts regarding the evolution of the item between now and 2050. Where there was a significant gap between what was expected to be achievable by 2030, 2040 and 2050, the item is highlighted with a **red mark**, denoting that it is an area that will require particular action in its implementation. Where there was insufficient information, or insufficient agreement among responses, the item is highlighted with an **orange mark**, denoting that it is an area that requires additional information and consultation.

- **[data gap] Data collection and monitoring**: Improved access to data helps cities measure, monitor and manage energy use and environmental impacts. Regular tracking of energy-related metrics allows cities to set a benchmark for energy usage and target specific areas where savings can be quickly achieved (ACEEE, 2019). Local government authorities should collect energy data covering public buildings and infrastructure, private buildings, and transportation, linking to existing databases (e.g. property registers). This would enable them to make the case for priority interventions, and evaluate the effectiveness of existing

policies over time. In turn, this data would help to communicate the importance of resilient and low-carbon buildings through evidence-based analysis and gain the support of local citizens and relevant stakeholders. The use of public participation geographic information system (PPGIS) can promote empowerment and ensure the inclusion of people who otherwise have a little voice in the public arena. PPGIS can work as a bridge between the experts traditionally involved in urban planning and the participatory planning that draws on the local expertise (Brown, n.d.).

- **Digital tools**: Support the increased use of tools that use data and information, such as geographic information system (GIS) mapping, satellite images, cost data, benefits analysis and life-cycle analysis to make science-based decisions in the urban planning process. While there is no commonly agreed definition, the emerging definition of smart cities is that they are monitored through information and communication technology and digital technologies, with the goal of using "enhanced real-time data, automated utility systems and digital communication tools to increase the provision of urban services (e.g. transport, energy, water) and governance in a way that is cost-effective and accountable" (OECD, 2016). Smart-city applications include among others: smart streetlights, building management systems, smart electric grids, and intelligent traffic and transit solutions. Smart solutions may also offer valuable applications to enhance the resilience of the built environment in particular to climate impacts, as discussed in the "Resilience" section. Some estimates indicate that a comprehensive suite of smart solutions across all Southeast Asian cities could remove up to some 270 000 kilotonnes of GHG emissions annually – equivalent to Laos' total annual GHG emissions (McKinsey Global Institute, 2018). *Stakeholder feedback: There is consensus that digital tools are largely lacking for urban planning, and their use would increase to become widespread by 2050.*

- **Street lighting**: Support the switch to smart and efficient lighting, including promoting solar street lighting technologies on the exterior of buildings and streets where relevant, and effective on a whole life cycle basis. Smart lighting can include sensors and controls and can be integrated with other environmental and site condition information, such as traffic. Appropriate measures should be taken to minimise impact on population health and biodiversity by using appropriate light diffusion devices and lighting schedules. Street lighting typically represents 5% or more of cities annual operational budgets, especially in resource-constrained cities, and can therefore generate significant savings, while better quality and extension of street lighting can also contribute to crime reduction at night. *Stakeholder feedback: There is strong consensus that smart street lighting is currently limited in its use, but would become more and more widespread, reaching "all" or "most" jurisdictions by 2050.*

- **[ambition gap] Water management**: Support the increased use of water management technologies that reduce water run-off and increase landscape permeability and rainwater retention. This can support resilience against floods and improved health of soil and underground aquifers. The measurement of rainwater flows through downpipes, into tanks, and drains through smart sensors can enable urban planning authorities to identify places where green infrastructure is needed to improve drainage and mitigate UHI effects. *Stakeholder feedback: There is consensus that storm-water management is only partly incorporated into urban plans currently. There is consensus that it could be mostly incorporated by 2040 to 2050.*

- **Waste management**: Support the increased use of waste and wastewater storage and treatment technologies that can reduce energy use from buildings. As in other regions, the growth of Asian cities is accompanied by fast-rising amounts of solid waste generation due

to the twin trends of population growth and higher levels of material consumption. Solid waste generation per capita has significantly increased in all Southeast Asian cities. As in all cities, the "3Rs" (reduce, reuse and recycle) principle should be embedded into municipal solid waste strategies of Asian cities. In Bangkok, for example, per capita solid waste generation grew from 535 kilogrammes (kg) per year in 2005 to 641 kg per year in 2013 (the OECD average was 556 kg in 2013) (OECD, 2016). In Southeast Asian cities, the bulk of waste is disposed in landfills, as well as in unregulated dumps, causing serious social, health, safety and environmental consequences, notably through disease vectors and methane release. Waste management is one of the core functions of city authorities but remains a crucial challenge in many cities across the world, often representing 20-50% of municipal annual budgets (World Bank, 2018). In addition, waste generated in informal settlements is often dumped into local streams and drainage canals and can exacerbate flooding risks. *Stakeholder feedback: Waste management policies appear to be somewhat integrated to urban plans, and there is strong consensus that they could be fully integrated by 2040 to 2050.*

- **[ambition gap] Vegetation**: Landscaping and vegetation can support improved resilience to excess storm-water, reduced need for heating and cooling, and improved air quality through measures such as green roofs, green walls, trees and parks. In particular, urban parks are critical in improving the urban quality of life by, cooling cities, and in acting as a sink for GHG emissions and other atmospheric pollutants. However, with few exceptions, most cities in Asia do not meet the World Health Organization's recommendation of 9 m^2 of green space per urban dweller. Consequently, many cities are actively engaged in recovering fringe areas such as wetlands or refurbishing parks that have fallen into disrepair, and developing green spaces through linear parks and urban reforestation initiatives. Vegetation measures should prioritise the use of indigenous plant species. *Stakeholder feedback: Currently, urban ecology is largely absent from urban planning strategies in the region, and there was strong consensus it would be only be mostly integrated across the regions by 2050.*

Box 3 • Regional examples of technologies for urban planning

China

In the city of Guiyang, China, the urban development strategy includes the mitigation of the heat island effect by creating ventilation corridors. After having studied the wind patterns and the building design and urban layouts have been planned to create a wind path across the city. Other measures taken include linking green belts and water bodies with the major roads and railway lines to form wind corridors to improve the urban air flow.

Singapore

The UHI effect has affected outdoor thermal comfort in Singapore. This is expected to worsen with increased urban growth and climate change impacts. The Cooling Singapore project was launched in 2017 to mitigate the negative effects of UHI. The research project has resulted in 86 strategies across 7 areas – greenery, urban geometry, water features, materials and surfaces, shading, transport, and energy. As part of this initiative, with the extensive use of vertical greening and high-rise terraces and gardens, Singapore is becoming a role model for many other cities in Asia. While green walls are aesthetically appealing, they also have added benefits including providing insulation, reducing solar gains to buildings and providing evaporative cooling within the city, along with CO_2 absorption.

The ASEAN Smart Cities Network

The ASEAN Smart Cities Network (ASCN) is a collaborative platform of 26 cities from the ten ASEAN member states working towards the common goal of smart and sustainable urban development by sharing cross-cutting lessons and resources. The core elements of the ASCN will be: 1) city-specific action plans for smart-city development (2018-25); 2) ASEAN Smart Cities Framework; 3) annual meeting of the ASCN; and 4) a twinning

programme pairing up each pilot city with one of ASEAN's external partners, forming mutually beneficial partnerships for co-operation on smart-city development. The overall objective of ASCN is to facilitate such co-operation and catalyse bankable projects with the private sector.

Savings from LED streetlights in the Philippines

Quezon city in the Philippines had purchased 6 055 light-emitting diode (LED) streetlights as of March 2016, which are now installed, representing about 12% of the of city's streetlights, generating electricity savings of USD 22 000 per month (ESMAP, 2016).

Finance for urban planning

Finance can enable increased action towards zero-emission, efficient and resilient buildings when coupled with urban planning.

Financial tools particularly relevant to urban planning include:

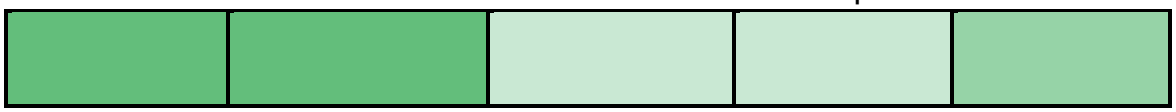
- **Urban development funds**: Dedicated funding for urban development projects, which can be directed towards sustainable urban development projects.
- **Infrastructure funds**: Dedicated funding for infrastructure projects, which can be directed towards sustainable infrastructure projects.
- **Dedicated credit lines**: Funding delivered through banks for a specific purpose, such as sustainable buildings, construction or development projects. Dedicated credit lines to national or local governments can also be used to establish a revolving loan fund, which collects repaid loans for energy efficiency projects and reinvests them in additional energy efficiency projects.
- **Risk-sharing loan/loan guarantee/concessional loan**: Large organisation (such as a government, international bank or aid organisation) cover the risk of payment default, offering below-market interest rates or offering longer grace periods for repayment to enable banks to fund a project with lower costs and therefore obtain better loan terms.
- **Green bonds**: Bonds that can be used to bundle funding for projects with climate or environmental benefits.
- **Preferential tax**: Direct funding from the government to reduce or eliminate the tax for sustainable products and services.
- **Grants and rebates**: Direct funding to overcome upfront cost barriers, provided by the government, organisation or programme either through a competitive process (grants) or during or after the purchase of a sustainable product or service (rebates).
- **Procurement purchase and lease**: The purchase or lease of sustainable products and services. Leasing enables the use of energy-efficient products on a rental basis to reduce a capital expenditure.
- **Community finance and crowdfunding**: Collective funding from a large number of people connected either locally or through a call for funding.
- **Participative budgeting:** Citizens engage in multiple rounds of debates and deliberations, and ultimately vote on how a certain percentage of the municipal budget is spent. This can contribute to a more equitable distribution of city services.

Capacity building for urban planning

Information combined with capacity-building activities can increase overall awareness, improve the decision-making process and encourage more sustainable choices. Training for professionals working directly with the built environment can enable increased resources and capacity to deliver sustainable urban planning.

The types of capacity-building activities relevant to urban planning are mapped in Table 3, where the darker the colour, the higher the impact that capacity-building type has for this activity.

Table 3 • Capacity building for urban planning in Asia

Training within government	Training of professionals	Training of product/material manufacturers	Training of financiers and developers	Training of general public
				

Note: The darker the colour, the higher the impact that capacity building type has for this activity.

Details regarding the most relevant capacity-building activities are explained below:

- **Training within government**: Provide training on the integration of sustainable urban planning strategies across all relevant departments and levels of government, including those responsible for spatial planning, zoning regulations, and procuring and managing services such as waste and water management. Build capacity in collecting and using data to inform policies and urban plans. Finally, training on how to work in collaboration across stakeholder groups including governmental and non-governmental actors.
- **Training professionals**: Build capacity and awareness among service providers, including urban planners and designers, as well as technology providers about the broader framework of sustainable development goals and the implications for urban planning solutions. This will be important to ensure co-ordination and shared goals among relevant government and non-government organisations for better implementation and enforcement of urban planning policies.

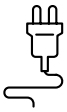
Further details regarding capacity-building activities are provided in the section Roadmap support: Enablers .

Multiple benefits of sustainable urban planning

Many benefits can be achieved through sustainable urban planning, and many of these are aligned with several SDGs, especially with Goal 11 (sustainable cities and communities).

Some of these benefits are described in Table 4, although many of them require further analysis to quantify them:

Table 4 • Multiple benefits of urban planning

	Environment
	• **Emissions reductions –** sustainable urban planning delivers emissions reductions through the reductions in emissions from transport thanks to TOD and encouraging walking and cycling, and absorption of CO_2 through open green spaces. • **Air quality –** sustainable urban planning reduces air pollution through the reduction of transport-related emissions through TOD, open green spaces, and encouraging walking and cycling.
	Energy
	• **Energy savings –** sustainable urban planning through mixed-use developments and TOD reduces commutes and supports mass transit, walking and cycling. • **Energy security –** sustainable urban planning delivers buildings, cities and transport systems that put less strain on energy systems by reducing energy demand and favouring local renewable energy sources. • **Energy prices –** sustainable urban planning supports integrated buildings, transit and energy systems that optimise potential synergies and energy flows so as to reduce energy demand and peak loads, lowering network infrastructure and system costs.
	Economy
	• **Productivity** – sustainable urban planning increases the efficiency of the urban infrastructure and can enable increased productivity through reduced commuting times, also improving health and well-being. • **Asset value** – sustainable urban planning can increase the asset value of homes, businesses and transit systems by creating more liveable cities.
	Society
	• **Poverty alleviation** – sustainable urban planning reduces building operation and transport costs, and can deliver improved access to employment and other services for vulnerable populations. • **Health and well-being** – sustainable urban planning can support increased physical and mental health through improved access to employment, transit, greater use of active modes for commuting (walking, biking), reduced air and noise pollution, reduced time spent in transport, green spaces, and other amenities. • **Safety and security** – sustainable urban planning by mixed-use and transit-oriented planning can support improved social integration and urban lighting enhancing safety and security.

Activity 2: New buildings

This section addresses measures to reduce the operational energy (and consequently operational carbon) in new buildings. Integrated policies for new buildings can avoid locking-in emissions from inefficient buildings for multiple decades. Fully decarbonising buildings over their whole life cycle will also require measures to reduce the embodied carbon of materials, addressed in "Activity 6: Materials", and measures to increase the share of renewable energy, both in distributed generation and in the electricity sector, as described in "Activity 8: Clean Energy".

Box 4 • New buildings in Asia: Trends and challenges

Among global regions, Asia is expected to see the greatest rise in floor area in the coming years, with another 65% floor area built between now and 2050, or another 70 billion m2 in ASEAN, China and India alone (IEA, 2017). Most of this growth in floor area will be in the residential sector, where increasing incomes are leading to higher ownership rates and larger households.

India and Southeast Asia are some of the hottest regions in the world, but ownership of room air conditioners is very low (IEA, 2019e). As access to space cooling increases, so should the quality of the building envelope to ensure that the additional energy demand for cooling does not put excess strain on the energy system, and consumer bills. In China, heating demand is a stronger driver, which also should be optimised through efficient building fabric.

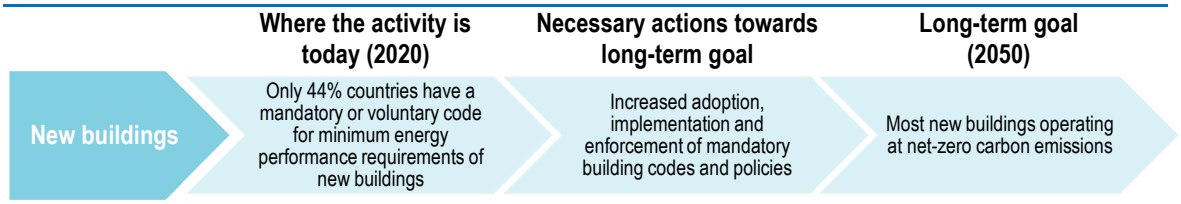
Yet with the exception of China, Japan and Singapore, the construction of new buildings in these regions is largely not covered by mandatory building codes. As seen in the 2019 Global Status Report, only China, Japan, Korea and Singapore have mandatory building energy codes that apply to both commercial and residential buildings. Few other countries have mandatory or voluntary codes for part of the sector including India, Indonesia, Malaysia, Sri Lanka, Thailand and Viet Nam. The remaining 15 countries in South, East and Southeast Asia have no building energy codes in place currently, so quickly developing enforceable minimum standards for the quality of the building stock being built is crucial.

Even in those countries with building codes, there is a lack of effective implementation frameworks, and the level of enforcement is low. This is mainly due to the complex governance in some of the countries, and lack of financial and human resources in the enforcing agencies. For example, India's Energy Conservation Building Code has been implemented in only 13 out of 35 states. Despite the absence of building codes, however, the market for green buildings is growing, with voluntary building certification widespread across the region (GlobalABC/IEA/UNEP, 2019).

In India, the Bureau of Energy Efficiency (BEE) estimated that as much as 60% of the base case energy consumption could be avoided through better design including better bricks, better ventilation, shading and better windows (Prayas [Energy Group], 2016).

Key actions for sustainable new buildings

Figure 16 • Key actions for new buildings in Asia



Key actions for new buildings in Asia include:

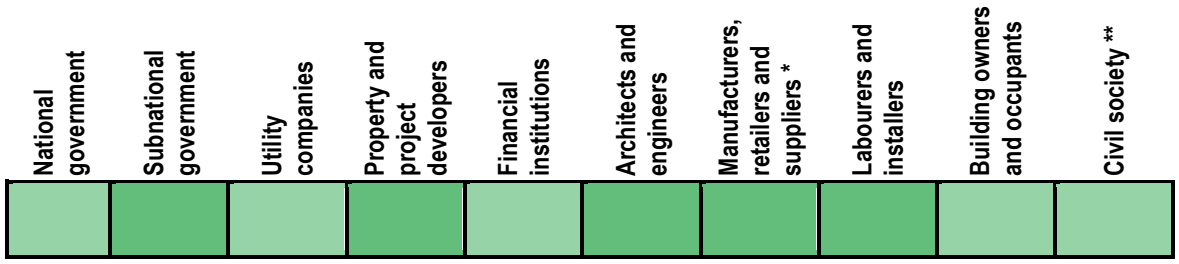
- **Develop a roadmap strategy**. Develop a locally appropriate strategy for decarbonising buildings using an efficiency-first and whole-life-cycle carbon assessment approach, including a strategy for decarbonising construction materials and energy aiming to reach new buildings that are ready to operate at net-zero carbon by 2030.
- **Develop and implement mandatory energy codes**. Transition existing voluntary to mandatory codes that set the minimal energy efficiency and thermal performance in new buildings. Codes should set or refer to guidelines for locally adapted bioclimatic design principles, and increasingly incorporate climate resilience and low embodied carbon materials.
- **Strengthen building energy codes**. Ensure that there is a building code improvement cycle that strengthens the performance requirements every 3-5 years with aspirations of achieving zero carbon emission codes for between 2030-2040. Integrate building codes with resilience, materials and urban planning strategies.
- **Minimise the need for space conditioning.** Cooling demand is the fastest-growing service demand. Focus on using highly efficient cooling systems where necessary but prioritise the use of passive design in order to maintain thermal comfort.
- **Enable sustainable building investments**. Enable increasing design and construction of sustainable buildings by increasing access to and use of finance to enable private investment. Link these efforts to new and emerging consumer lending models.
- **Governments lead by example**. Develop policies that ensure all new government buildings are low-emission and efficient, promote demonstration or pilot projects to illustrate best practice.
- **Increase the use of building design tools**. More integrated design processes and simulation or modelling tools such as building information modelling (BIM) can help ensure higher performance in a cost-effective manner. For new development, have BIM as part of the design brief.
- **Increase material efficiency** through optimised design, the reuse of existing buildings or materials, and other materials measures to reduce the embodied carbon of materials (see Activity 6: Materials); **reduce operational carbon** through the provision of clean energy (see Activity 8: Clean energy).
- **Increase awareness and information**. Awareness of the multiple benefits of more sustainable buildings will enable consumers to make better choices and can enable more advantageous financing.

Stakeholders for sustainable new buildings

In Asia, the key stakeholders for sustainable new buildings include those that can influence new buildings and those that can deliver the results of zero-emission, efficient and resilient buildings. Additional stakeholders include those that can support the process through research, funding, training and making technologies available.

These stakeholders are mapped in Table 5, where the darker the colour, the higher the impact that stakeholder group has on the activity and the more essential it is to delivering the roadmap targets.

Table 5 • Stakeholder mapping for new buildings in Asia



* of appliances and materials

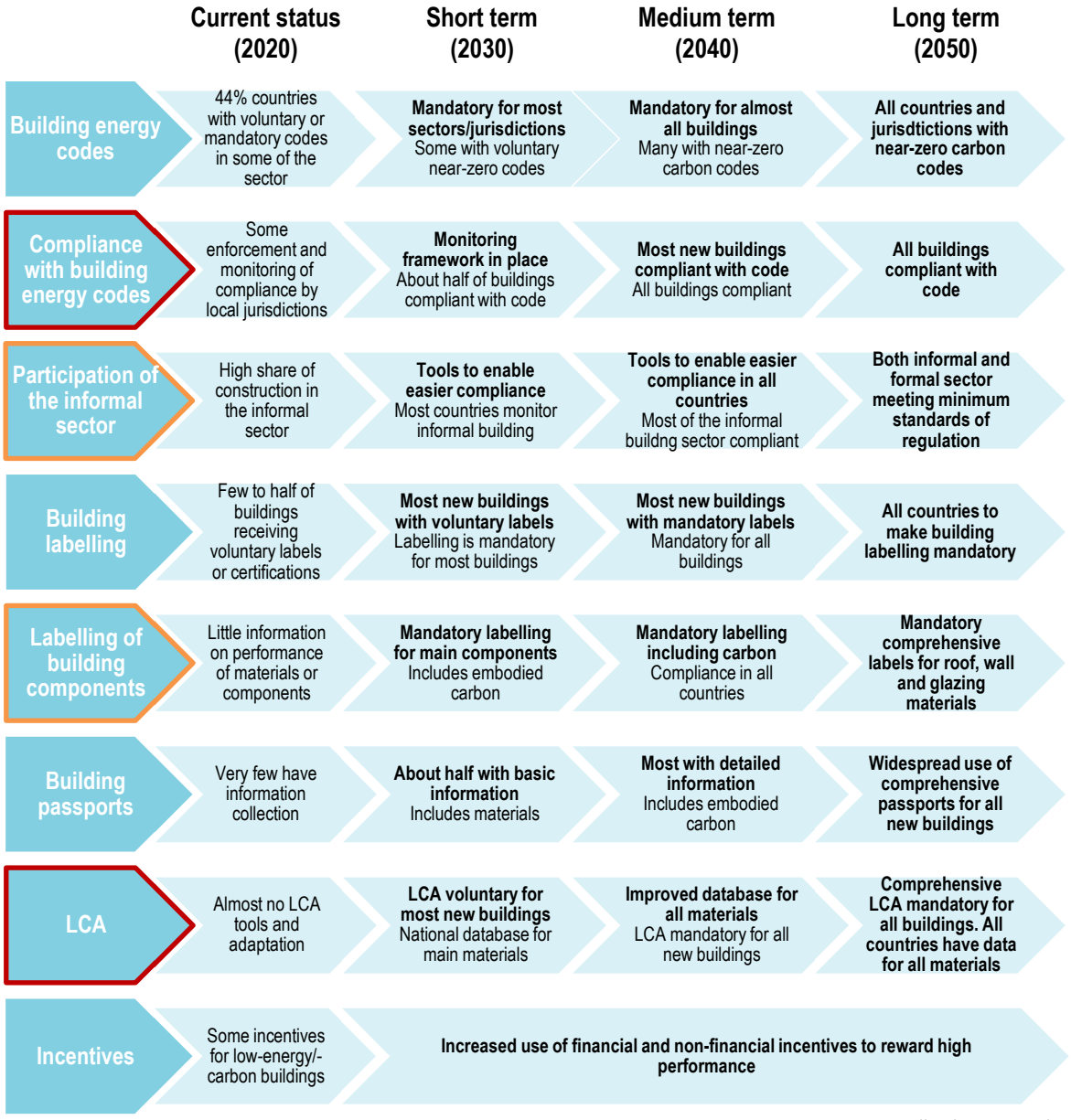
** including academia, NGOs, research institutions, social networks and community associations.

How to read: The darker the colour, the higher the impact that stakeholder group has on the activity and the more essential they are to delivering the roadmap targets.

Policy for sustainable new buildings

The policies listed in Figure 17 represent key tools that policy makers have at their disposal to increase the performance of new buildings, to reach zero-emission, efficient and resilient buildings as soon as possible. These policies are applicable both at national and subnational levels, and will need to be supported by enabling policies and programmes as detailed in the subsections below.

Figure 17 • Policy timelines for new buildings in Asia



Notes: The **proposed regional target** is in **bold**. Below that is the proposed accelerated target. A red border indicates an ambition gap for that target (more details below); an orange border indicates a gap in data or consensus (more details below).

Details on the policy targets for new buildings are outlined below. For each item, in *italic* is a description of the consensus among the consulted local building experts regarding the evolution of the item between now and 2050. Where there was a significant gap between what was expected to be achievable by 2030, 2040 and 2050, the item is highlighted with a **red mark**, denoting that it is an

area that will require particular action in its implementation. Where there was insufficient information, or insufficient agreement among responses, the item is highlighted with an **orange mark**, denoting that it is an area that requires additional information and consultation.

- **Building energy codes**: Building energy codes or standards provide minimum requirements for building components or for building performance that can enable zero-emission, efficient and resilient new buildings. Building codes should be mandatory and cover all types of buildings, and be based on a whole-life-cycle carbon approach (including operational carbon and embodied carbon). These aim towards net-zero emission buildings at lowest cost by ensuring highest efficiency levels first. Building codes should include, or refer to, locally adapted bioclimatic design principles to optimise passive design, and be linked to occupancy or building permits to be most effective. First building codes should be prescriptive in format, evolving into performance-based codes. Specific standards, guidelines and tools for social housing and the informal sector can be used to facilitate compliance within this sector. More information on building codes can be found in Box 5. *Stakeholder feedback: There is broad consensus that net-zero building codes could be set on a voluntary basis from 2030 and mandatory for all new buildings by 2050. There is agreement that building energy codes still need to be developed for many countries that currently have none in order to achieve the overall long-term objective.*

- **[ambition gap] Compliances with building energy codes**: Compliance with, and enforcement of, building codes is crucial yet challenging, as it is often up to subnational governments to enforce, despite variations in human and financial resources. A monitoring framework for compliance checking, accessible tools and extensive capacity building will facilitate compliance and even enable compliance within sectors such as the informal sector and the social housing sector. *Stakeholder feedback: Responses indicated that monitoring and enforcement was adequate but not widespread, due to the codes being voluntary. A focus on broader mandatory codes would help ensure "most" new buildings reach compliance by 2050.*

- **[data gap] Participation of the informal sector**: Capacity building, accessible construction guidelines and tools, and wide stakeholder engagement will be key to increase the compliance with codes within the informal building sector. *Stakeholder feedback: The high participation of the informal construction sector was raised by several respondents as a key barrier.*

- **Building labelling**: Quantitative building energy labelling can be used to assess "as designed" building performance on a scale of less to more efficient. Labelling enables increased information sharing and awareness for consumers and investors. Labelling can also be linked to incentives and financial tools. Certification such as green building certification is included in this policy as another form of assessing performance. Labelling and certification systems should be continually monitored and revised to ensure the top rating is truly reserved to the top-performing buildings of the market. *Stakeholder feedback: There is strong consensus that labelling will become widespread, being adopted by "most" to "all buildings".*

- **[data gap] Labelling of building components**: The availability of robust information on the performance of individual building components and materials is key for designers to optimise building design, and perform robust LCA based on whole-life performance. Key performance parameters include the thermal transmittance of materials, the solar heat gain coefficient (SHGC) or solar factor of glazing, and the reflectance of surface finishes. Additional information should eventually include embodied carbon, particularly for materials whose embodied carbon can be significant (insulation, glazing, window frames etc.).

- **Building passports:**[10] Building passports or logbooks can be used to track information about the building, materials, systems, energy use, renovations and other real estate information to improve decision-making processes. At the time of handover of a new building, a new building passport could include: floor area schedules, bill of quantities, embodied energy of materials, description of systems, maintenance schedules and estimated energy consumption. During its operational phase it may be completed with further information (see "Activity 4: Building operations"). *Stakeholder feedback: The region does not have widespread collection of building information, but the respondents felt there was potential for the adoption of this approach alongside building information management tools such as building information modelling (BIM) and building management systems (BMS).*

- **[ambition gap] LCA**: Decisions regarding the building use, design and choice of materials should consider the entire lifetime of the building and its components. National databases containing information on the embodied energy and carbon of construction materials will be necessary to undertake comprehensive life-cycle impact analysis of design choices. *Stakeholder feedback: The respondents in the regions stated that few buildings are designed with LCA in mind and that it was unclear when such an approach would be more widely adopted.*

- **Incentives**: Fiscal incentives should be awarded to the very best performing buildings to enable the uptake of most novel technology and tools. Criteria for obtaining fiscal incentives should be updated over time. Non-fiscal incentives, such as expedited permits or increased floor area allowances, are also powerful in encouraging lower-energy new buildings. *Stakeholder feedback: Views were that existing fiscal incentives were focused on rebates or reductions on taxes but that these would be phased out in the future as the market matured. There is consensus that growth in non-financial incentives will be modest. The most relevant forms cited are expedited permitting, reduced permit fees, special crediting schemes and increased scope.*

Box 5 • What is a building code?

Building energy codes, also known as "energy standards" for buildings, "thermal building regulations", "energy conservation building codes" or "energy efficiency building codes", are the key policy instrument used by governments to reduce the energy consumption of buildings. Such codes consist of a set of mandatory minimum energy performance requirements designed to regulate energy use in buildings. They can cover both new buildings and existing buildings undergoing renovation or alteration. Architects and engineers use the functional energy requirements stated in building energy codes to design buildings that meet the required standards (IEA, 2013a).

Building energy codes can be adopted as part of the larger body of building codes covering other aspects of a building construction's requirements, such as safety and structural integrity, that are all necessary to be satisfied as a condition for approval to construct and occupy buildings.

[10] A building passport is a document or logbook that is used to store and track information about the building: basic characteristics, materials, systems, energy use, renovations and other building information.

Box 6 • Regional examples of policy action for new buildings

India: **Building code, certification and incentives**

The Ministry of Power of India launched ECO Niwas Samhita, an Energy Conservation Building Code for Residential buildings, to promote energy efficiency design and construction of homes, apartments and townships. Given the pace at which building stock is growing in India, it is a landmark policy ushering energy efficiency into the buildings sector, relevant for all contributors to the construction process. Implementation of the code is at the state level with national support.

The Ministry of Environment, Forest and Climate Change (MoEF&CC) offers fast-track environment clearance to new building projects that are registered under a Green Rating for Integrated Habitat Assessment (GRIHA), Indian Green Building Council (IGBC) or Leadership in Energy and Environmental Design (LEED) rating system. The notification became effective in 2011. The copy of registration certificates along with other documents required for environmental clearance are required to be submitted by the agencies seeking fast-track clearance under the scheme.

Similarly, different states have launched policy initiatives in terms of extra floor area ratio, financial assistance, subsidies on total fixed capital investments, reduction in permit fees for buildings, etc., which demonstrate compliance with one of the existing rating systems for new buildings, such as GRIHA, IGBC or LEED.

China: Technical guidance for low energy buildings

The Passive Ultra-low Energy Green Building technical guidance for residential buildings was issued by the Ministry of Housing and Urban-Rural Development (MoHURD). The primary energy consumption for cooling, heating and lighting has to be below 60 kilowatt-hours per m^2 (kWh/m^2), with a specific requirement of heating and cooling demand depending on the climate zone.

China also launched the technical standard for nearly-zero-energy buildings GB/T 51350-2019, which was put into action on 1 September 2019.

The 13th Five-Year Plan for the construction industry issued by MoHURD includes a commitment for all new civil buildings to meet energy efficiency 20% higher than that of 2015, and expects that by 2020 green buildings in urban areas will account for at least 50% of new construction (China Academy of Building Research, 2019).

Malaysia: Building codes for all buildings

Malaysia has codes for energy efficiency and use of renewable energy for non-residential (MS 1525) and residential (MS 2680) buildings. The code has guidelines on energy-efficient measures relating to the building design as well as systems for new and existing buildings.

Korea: Zero-energy building code certification

The Korean Building Code includes provisions for zero-energy buildings (ZEB), which is defined as a "green building" that has minimised the building load and energy requirement through the supply of new and renewable energy (Prof Xu, 2018). The Ministry of Land, Infrastructure and Transport and Ministry of Trade, Industry and Energy developed the ZEB certification system in 2017.

Singapore: Green building standards

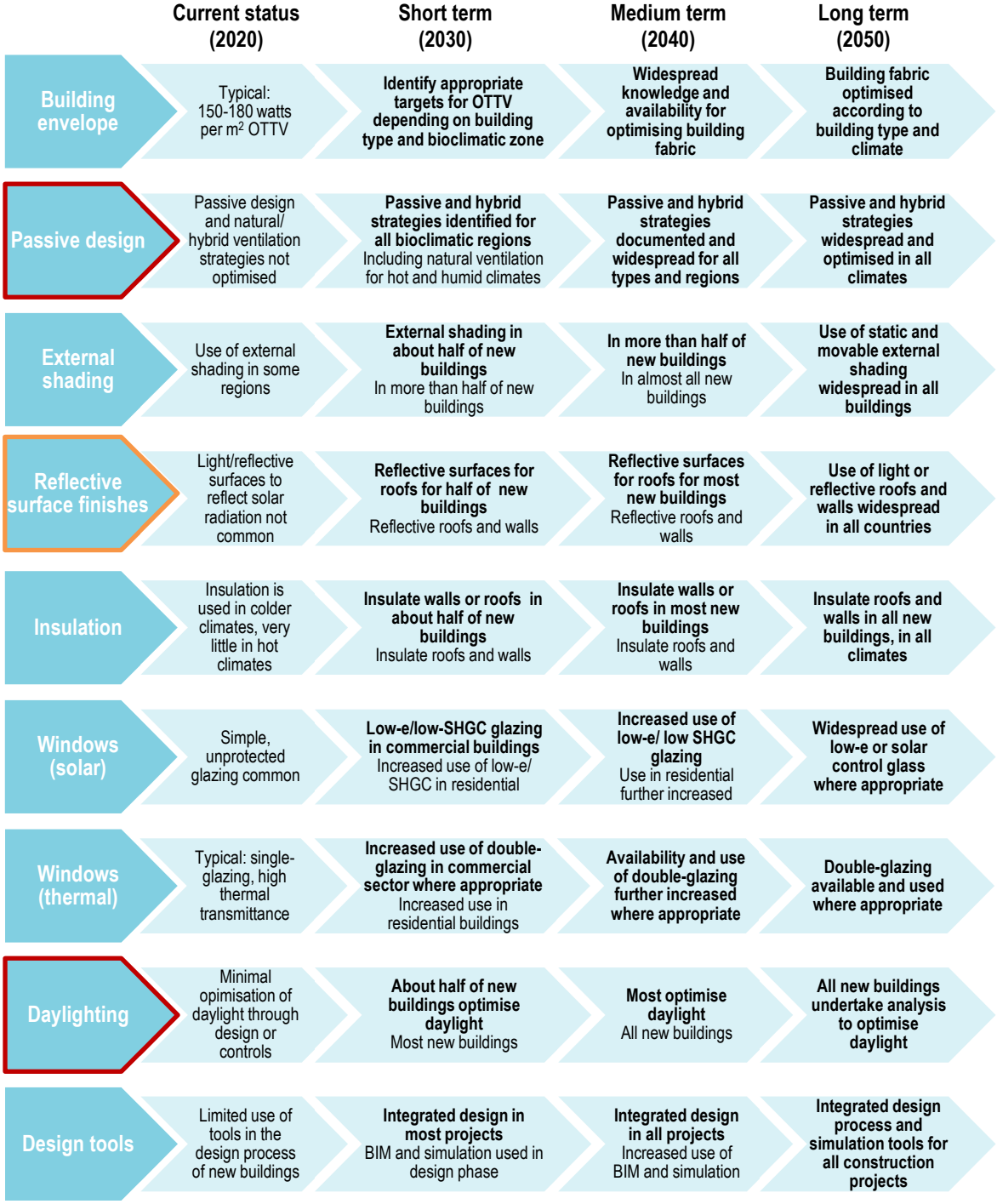
Since 2008, all new buildings with a gross floor area of 2 000 m^2 or more in Singapore are required to meet the green building standard. In 2018, the Building Construction Authority launched the Super Low Energy (SLE) Programme to push the boundary of energy efficiency towards "super" low or net-zero energy buildings in the tropical urban environment. The SLE implementation is supported by an innovation programme (Green Buildings Innovation Cluster) and the Green Mark scheme for wider adoption. This includes technology roadmapping, demonstration, building certification, and a series of resource development and engagement initiatives.

Technology for sustainable new buildings

Figure 18 lists the key technologies or strategies needed to reach the long-term objective of decarbonising the buildings sector.

Specific targets and timelines for sustainable new building technologies are outlined below:

Figure 18 • Technology timelines for new buildings in Asia



Notes: OTTV = overall thermal transfer value. The **proposed regional target** is in **bold**. Below that is the proposed accelerated target. A red border indicates an ambition gap for that target (more details below); an orange border indicates a gap in data or consensus (more details below).

Details on the technology targets for new buildings are outlined below. For each item, in *italic* is a description of the consensus among the consulted local building experts regarding the evolution of the item between now and 2050. Where there was a significant gap between what was expected to be achievable by 2030, 2040 and 2050, the item is highlighted with a **red mark**, denoting that it is an area that will require particular action in its implementation. Where there was insufficient information, or insufficient agreement among responses, the item is highlighted with an **orange mark**, denoting that it is an area that requires additional information and consultation.

- **Building envelope**: The OTTV is a measure of the building envelope performance including conduction and radiation heat transfer. This includes the performance of the building structure, insulation and windows. Lower OTTV can be achieved through optimised material choices and passive design strategies including building form, orientation, thermal mass, shading, the use of reflective surfaces to limit solar gain, and the use of vegetation, for example in cool roofs. Advanced building envelopes should be a key immediate priority for China given its large heating demand (IEA, 2013b).

- **[ambition gap] Passive design**: Strategies for the most cost-effective combination of thermal performance of the building fabric, control of solar gains and ventilation, and daylight are highly dependent on the building type, how it will be used, and the macro- and micro-climate in which it is situated. Therefore, passive design strategies should be developed for specific bioclimatic regions and specific building types. These locally adapted design guidelines can ensure that passive strategies can be optimised before relying on active systems. *Stakeholder feedback: The adoption of passive cooling strategies is currently limited, with few examples of naturally or mixed-mode ventilated buildings in tropical climates. There was lack of consensus that such approaches could be adopted for 2040 and beyond.*

- **External shading**: External shading in the form of horizontal, vertical, fixed or movable elements can be the most cost-effective method of blocking out solar radiation. Good shading can have the same effect on reducing the heat gain through windows as solar-performance glazing. *Stakeholder feedback: External shading is not widespread today; however, there was strong consensus over its increased adoption, particularly in the residential sector.*

- **[data gap] Reflective surface finishes:** Light-coloured surfaces or surfaces with reflective pigments reflect incoming solar radiation, therefore reducing the temperature of the surface. Reflective surface finishes are most effective on the surfaces most exposed to direct sunlight (generally the roof).

- **Insulation**: Insulation is one of the components of OTTV that should have specific targets for hot locations and cold locations. A material's insulation performance is determined by its thermal conductivity. "U-value" is also commonly used to express how much heat will transfer through a given thickness of a particular material, where the lower the U-value, the better the material is as an insulator. It is important to note that insulation can be effective in hot climates as well as in cold climates, and is most effective in the component of greatest surface area (i.e. the roof for low and flat buildings, walls for tall buildings). Note: the benefits of increased insulation should be assessed over a whole-life-cycle carbon assessment, given the high embodied carbon of traditional insulating materials. The extent of insulation required should be determined by cost-benefit analysis taking into consideration the local climate. *Stakeholder feedback: Respondents stated that insulation was applied in roofs and walls in a limited way but that its adoption provided opportunities to address future performance improvements.*

- **Windows (solar)**: The dominant source of heat transfer through glazing is through solar radiation. This can be reduced with low-e and low-SHGC glazing. Building design and advanced technologies can enable low solar heat gain during hot weather, while allowing visible light transmittance for natural daylighting; however, the most cost-effective way of avoiding excess solar gain is reducing the size of windows and providing shading, which should always be prioritised. *Stakeholder feedback: Low-e or solar-performance glazing is currently limited to high-end commercial buildings in the market though its application is seen as promising.*

- **Windows (thermal)**: Heat transfer by conduction through glazing can be reduced through a transition to double- or triple-pane glazing, which has lower thermal transmittance, or U-value. When produced at scale, these types of windows can be cost-effective. These windows also provide noise protection, improve thermal comfort, and can enable passive architecture and natural ventilation. Note: the benefits of double- or triple-pane glazing should be assessed through a cost-benefit analysis over the whole life cycle (for example using building simulation tools), also assessing the impact on embodied carbon, given the high materials and energy costs of glass manufacturing. *Stakeholder feedback: The use of double-glazing is not widely applied aside from in some commercial buildings but is an emerging portion of the market and is expected to be more widely taken up among new development and existing buildings over time.*

- **[ambition gap] Daylighting**: Access to external views and to daylight is essential for building occupant well-being, health and productivity. Building design should ensure that all spaces have access to natural light and views and have glare-free, adequate daylight levels for large portions of the day through improved control. However, there is a need to optimise the ingress of natural light with the control of excessive solar radiation. *Stakeholder feedback: There is limited design for natural daylight in buildings, but a view that about half of buildings could benefit from these strategies by 2050.*

- **Design tools**: The integrated design process of involving all disciplines of a building project from the early stages of the project enables the adoption of many more passive design measures than when disciplines are brought on at later stages. Other tools with significant potential to optimise passive measures and design choices include thermal and energy dynamic simulation, daylight simulation, and BIM. *Stakeholder feedback: There was strong consensus that these tools will become mainstream by as early as 2030.*

Box 7 • Examples of regional technologies for new buildings

Technology roadmaps for moderate and humid regions

The Innovation for Cool Earth Forum describes in its ZEB roadmap, developed under Japan's Ministry of Economy, Trade and Industry research programme, the key technologies and the timelines for their evolution, particularly targeted to warm and humid regions. Technology developments relating to insulation, surface finishes and sealing between now and 2030 focus on reducing the cost and improving the standardisation and efficiency of components, while from 2030 the focus will be to enable their market diffusion through market mechanisms. Measures such as shading and ventilation are already considered to be proven and ready for mass uptake by the market (Institute of Applied Energy, 2016).

Singapore's first net-zero energy building

The National University of Singapore's School of Design and Environment inaugurated the country's first net-zero energy building in January 2019. The building makes use of hybrid ventilation where fans provide air movement enabling thermal comfort at a high temperature set point, topped up with a chilled water system, and features a facade that optimises daylight. The building's energy demand was reduced through building design and efficient system choices such that its annual energy demand can be supplied by the electricity generated on its rooftop PV panels. The use of a hybrid ventilation system in a hot and dry climate makes it a demonstration project for the region, though its success relies on its occupants adapting to higher ambient temperatures and humidity than traditional air-conditioning systems, as well as higher air velocities.

More efficient construction techniques in China

3D printing is one of the latest technologies being implemented in China. It has helped to reduce construction time between 50-80%, thus enabling speedier, efficient and precise construction. The method also facilitates the use of recycled materials, with concrete making the construction more environment-friendly.

IFC EDGE Tool

The EDGE certification (for "Excellence in Design for Greater Efficiencies") was developed by the IFC, a member of the World Bank Group, as an international rating system for buildings in emerging markets. EDGE provides a broad framework for evaluating and monitoring projects, and provides third-party verification for green buildings, catering to different building types. IFC uses EDGE data, collected from the projects, to track investment opportunity in green buildings. As of 10 February 2020, over 16 million m^2 have been registered for certification under the EDGE system, delivering 385 317 megawatt-hours per year in energy savings.

The free of charge online design software enables users to explore the most cost-effective energy, water and materials efficiency measures for a building project. Savings are represented as comparisons with a standard building of the same typology and geometry in the same location. The types of measures which can be explored through this tool include the impact of shading; improved performance of roof, walls and glazing; surface finishes; glazing area; and more efficient systems, among many more. It can assess estimates of incremental cost, utility cost savings, and energy and water savings to optimise design choices, which are shown in an accessible manner that facilitates communication among the client, designer, and building and finance teams.

The asset manager Asia Green Real Estate requires all projects that apply for financing to commit to EDGE certification before they can receive funding. The firm finances residential and commercial properties across Asia, attracting both private and institutional investors looking to fulfill environmental, social and governance investor commitments. Asia Green Real Estate reports that its green projects have lower operational costs and lower vacancy rates. Overall the firm has invested in more than 2 million m^2 of green floor area, with an estimated energy savings of 22 399 460 kilowatt-hours (kWh) per year and CO2 savings of 13 410 tonnes/year.

Finance for sustainable new buildings

Finance tools relevant to increasing the performance of new buildings may include:

- **Urban development funds**: Dedicated funding for urban development projects, which can prioritise sustainable urban development projects.
- **Infrastructure funds**: Dedicated funding for infrastructure projects, which can prioritise sustainable infrastructure projects.

- **Dedicated credit lines**: Funding delivered through banks for a specific purpose, which can prioritise sustainable buildings, construction or development projects. Dedicated credit lines to national or local governments can also be used to establish a revolving loan fund, which collects repaid loans for energy efficiency projects and reinvests them in additional energy efficiency projects.
- **Risk-sharing loan/loan guarantee/concessional loan**: Large organisation (such as a government, international bank or aid organisation) covering the risk of payment default, offering below-market interest rates, or offering longer grace periods for repayment to enable banks to fund a project with lower costs and therefore better loan terms.
- **Green bonds**: Bonds that can be used to bundle funding for projects with climate or environmental benefits.
- **Preferential tax**: Direct funding from the government to reduce or eliminate taxes for sustainable products and services.
- **Grants and rebates**: Direct funding to overcome upfront cost barriers, provided by a government, organisation or programme either through a competitive process (grants) or during or after the purchase of a sustainable product or service (rebates).
- **Green mortgages**: Prospective homeowners can solicit additional finance as part of their mortgage to install efficient features and technologies in their future homes.
- **Procurement purchase and lease**: The purchase or lease of sustainable products and services. Leasing enables the use of energy-efficient products on a rental basis to reduce a capital expenditure.
- **Community finance and crowdfunding**: Collective funding from a large number of people connected either locally or through a call for funding.

Capacity building for sustainable new buildings

Information combined with capacity-building activities can increase overall awareness, improve the decision-making process and encourage more sustainable choices. Training for professionals working directly with the built environment can enable increased resources and capacity to deliver sustainable new buildings.

The types of capacity-building activities relevant to new buildings are mapped in Table 6, where the darker the colour, the higher the impact that capacity building type has for this activity.

Table 6 • Capacity building for new buildings in Asia

Training within government	Training of professionals	Training of product/material manufacturers	Training of financiers and developers	Training of general public

Note: The darker the colour, the higher the impact that capacity building type has for this activity.

Details regarding the most critical capacity-building activities are explained below:

- **Training within government**: Provide training programmes for central and local government on:
    - How to collaborate across multi-stakeholders, including how to communicate the multiple benefits of zero-carbon, energy-efficient and resilient buildings. This will require data collection and analysis on the outcomes of policies and programmes.
    - How to implement and monitor policies, through the development of tools, checklists, databases.
- **Training professionals**: Provide training programmes for service and product providers of buildings and construction (architects, engineers, contractors, etc.) and building owners regarding how to design more sustainable buildings, and how to comply with new building policies, programmes or incentives for sustainable buildings and construction. Develop educational programmes on primary, secondary, vocational, university and adult education levels, to enable increased knowledge of sustainable new buildings. Provide certification or accreditation for professionals in the sustainable construction sector.
- **Training financers and developers**: Develop tools and provide training for developers and financiers to be able to assess the relative benefits of zero-carbon, efficient and resilient buildings, to enable increased access to funding and increased demand for high performance buildings.

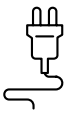
Further details regarding capacity-building activities are provided in the section Roadmap support: Enablers .

Multiple benefits of sustainable new buildings

Many benefits can be achieved through sustainable new buildings, and many of these are aligned to the SDGs, in particular Goal 7 (affordable and clean energy), Goal 11 (sustainable cities and communities), Goal 12 (responsible consumption and production) and Goal 13 (climate action).

Some of these benefits are described in Table 7, although many of them require further analysis to quantify them:

Table 7 • Multiple benefits of new buildings

	Environment
	• **Emissions reductions –** sustainable new buildings deliver GHG reductions because they consume less, and cleaner, energy. • **Air quality** – sustainable new buildings and zero-emission buildings reduce air pollution. • **Resource efficiency** – sustainable buildings reduce the use of materials for construction and increase the useful life of buildings and their components**.**
	Energy
	• **Energy savings** – sustainable new buildings are more energy-efficient. • **Energy security** – sustainable new buildings use less energy and put less strain on energy systems. • **Energy prices** – sustainable new buildings reduce energy consumption and peak loads, lowering network infrastructure and system costs.
	Economy
	• **Economic performance –** sustainable new buildings create employment for sustainability services and reduce building operation costs, freeing up resources to invest in other parts of the economy**.** • **Productivity** – sustainable new buildings can increase the productivity of students and employees through improved thermal comfort, lighting and acoustic comfort. • **Asset value** – sustainable new buildings have strong asset values and flow on effects for nearby properties and investment attraction.
	Society
	• **Poverty alleviation** – sustainable new buildings reduce building operation costs. • **Health and well-being** – sustainable new buildings deliver increased thermal comfort, light, noise and indoor air quality, improving physical and mental health and well-being.

Activity 3: Existing buildings

The performance of existing buildings can be assessed in terms of their operational use compared with benchmarks, which is covered in "Activity 4: Building operations", and in terms of the efficiency of the appliances and systems they are equipped with, covered in "Activity 5: Appliances and systems".

In order to reduce operational carbon emissions in existing buildings, renovations to the building envelope and systems will be crucial, and these should increasingly reach the standards of new buildings. Operational carbon can also be reduced by ensuring improved repair and refurbishment to extend the life of the building, by increasing intensity of use of buildings, and through increased occupancy and utilisation rates, and especially by combining all three (IRP, 2020).

Box 8 • Existing buildings in Asia: Trends and challenges

There is a striking lack of data regarding the quality and performance of the existing stock, and therefore also of the most effective retrofit measures to deploy.

However, in China, increasing attention is being turned to retrofitting existing buildings given the rapid growth in urban population and the need for housing and commercial space. It is estimated that less than 10% buildings are "energy-efficient" buildings, and significant savings can be achieved by fitting exterior insulation and upgrading the glazing. However, significant barriers have been identified including lack of data and information, high building density, strict government regulations concerning historic buildings, and the investment required (Yutong et al., 2017).

Singapore has an ambitious target of "greening" 80% of its building stock by 2030, and has set up funding mechanisms to enable this.

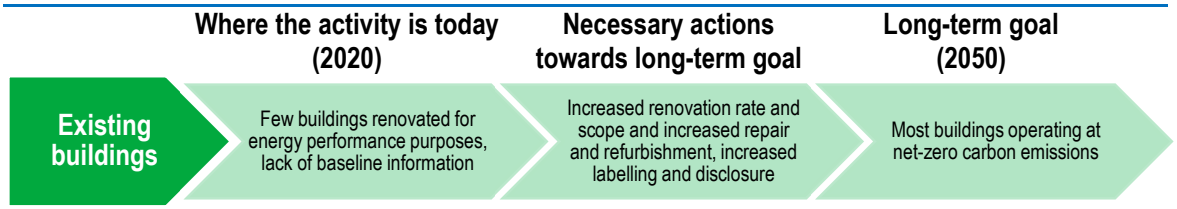
Even despite the high construction rates underway to meet the demand for growing urban populations, the refurbishment of existing buildings to meet ambitious performance standards should be prioritised, from a materials efficiency perspective.

The challenge for existing buildings will be to adapt to changing climates, rising ownership of devices and space cooling, increasing the quality of building environment, evolving cities, and the risks of natural disasters, as well as contributing to reducing carbon emissions. Incentives will be key to enabling these transformations.

It will be key to make the most of building upgrades that are happening for reasons other than energy performance and use this opportunity to upgrade the buildings systems, envelope and operation.

Key actions for sustainable existing buildings

Figure 19 • Key actions for existing buildings in Asia



Key steps to improving the performance of existing buildings include both increasing the number of buildings that are improved and increasing the amount of improvement that is achieved:

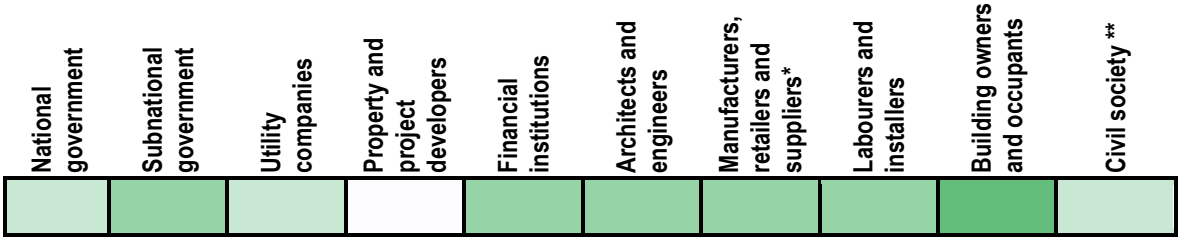
- **Decarbonisation strategy for existing building stock**. Improving the availability of data on the performance of existing buildings will enable the creation of baselines and strategies for their decarbonisation. In Asia, there has not been a strong focus on strategies to refurbish and retrofit existing buildings because the building stock has largely been built in the last 40 years. As the building stock ages, greater focus on low-emission refurbishment will be needed to avoid further life-cycle carbon emissions.
- **Increase renovation rates**. Annual renovation rates in the region should reach 1.5% by 2025 and 2% by 2040.
- **Increase the depth of renovation**. Enable deep energy renovations that reduce energy consumption of existing buildings by 30-50% or more. In Asia, the building stock that is greater than 25 years old will begin to require more substantial maintenance and refurbishment, particularly in large urban centres across the region, and putting in place standards and codes for existing building energy performance when undertaking refurbishments are needed.
- **Enable renovation investments**. Enable increasing renovation rates by increasing access to and use of finance to enable private investment in renovations.
- **Governments lead by example**. Develop policies that ensure existing government buildings are renovated to be low-emission and efficient. The region has not yet adopted widespread polices for emissions and energy efficiency for government refurbishment, with the exception of India and Singapore, and more policies like this can help both create a market and build capacity.

Stakeholders for sustainable existing buildings

In Asia, the key stakeholders for building retrofits include those that can influence existing buildings and those that can deliver the results of zero-emission, efficient and resilient buildings through retrofits. Additional stakeholders include those that can support the process through research, funding, training and making technologies available.

These stakeholders are mapped in Table 8, where the darker the colour, the higher the impact that stakeholder group has on the activity and the more essential it is to delivering the roadmap targets.

Table 8 • Stakeholder mapping for existing buildings in Asia



* of appliances and materials

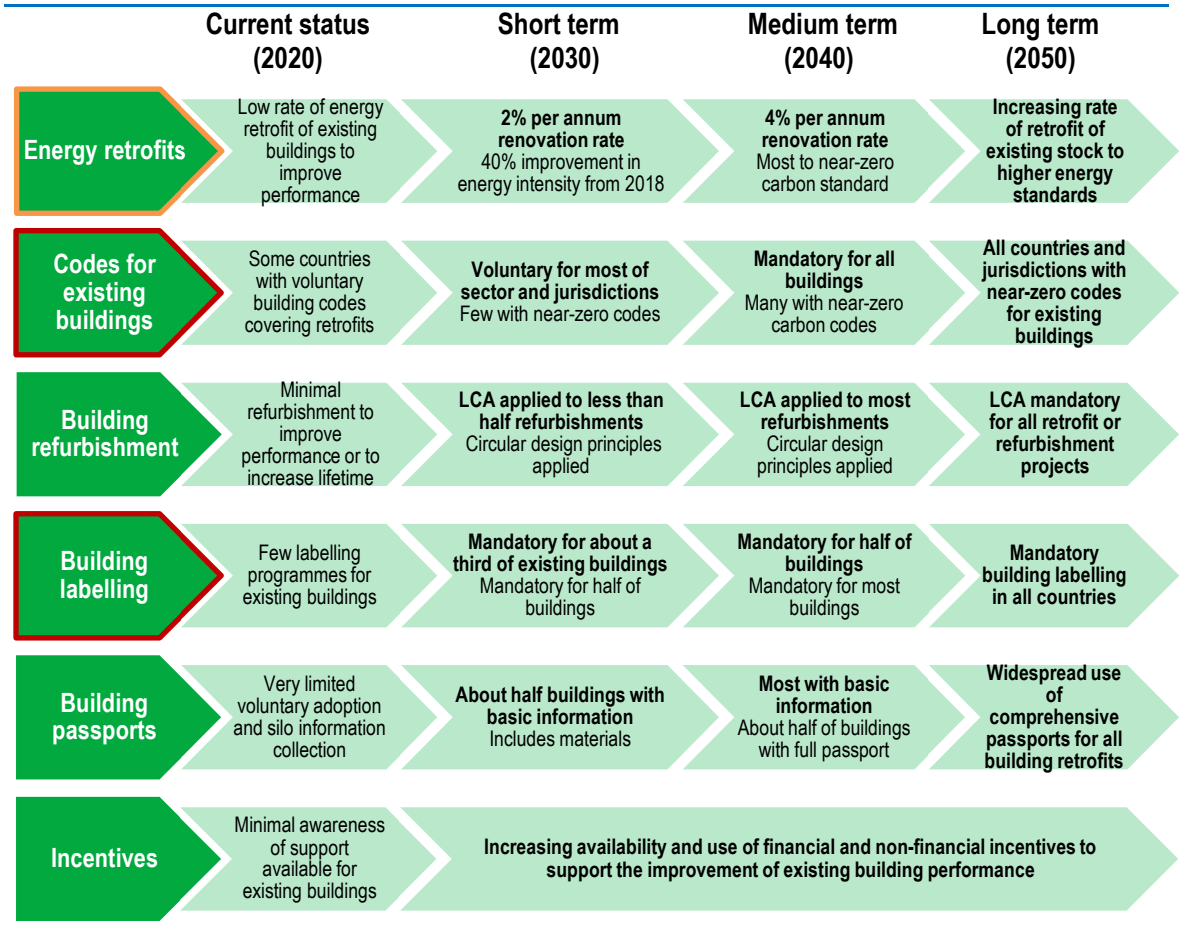
** including academia, NGOs, research institutions, social networks and community associations.

How to read: The darker the colour, the higher the impact that stakeholder group has on the activity and the more essential they are to delivering the roadmap targets.

Policy for sustainable existing buildings

Policy for existing buildings can be developed to enable all buildings to become zero-emission, efficient and resilient. Policies that typically cover only new buildings or major planned retrofits need to be adapted to existing buildings. Within the targets for sustainable building retrofits, the following sub-targets and timelines offer more details:

Figure 20 • Policy timelines for existing buildings in Asia



Notes: The **proposed regional target** is in **bold**. Below that is the proposed accelerated target. A red border indicates an ambition gap for that target (more details below); an orange border indicates a gap in data or consensus (more details below).

Details on the policy targets for existing buildings are outlined below. For each item, in *italic* is a description of the consensus among the consulted local building experts regarding the evolution of the item between now and 2050. Where there was a significant gap between what was expected to be achievable by 2030, 2040 and 2050, the item is highlighted with a **red mark**, denoting that it is an area that will require particular action in its implementation. Where there was insufficient information, or insufficient agreement among responses, the item is highlighted with an **orange mark**, denoting that it is an area that requires additional information and consultation.

- **[data gap] Energy retrofits**: An energy retrofit can be defined as an undertaking of structural, architectural, mechanical or electrical works with the aim of improving the

energy performance of an existing building. While these types of works are rarely carried out for their energy benefits alone, they should increasingly become widespread, and be more ambitious in their energy savings. According to the IEA Tracking Clean Energy Progress platform, the energy intensity of buildings needs to improve by approximately 20% in China and Southeast Asia, and by 40% in India, compared with the energy intensity in 2018 to meet the SDS (IEA, 2019b). Buildings should be retrofitted to their cost-effective potential as quickly as they can, even if this happens over the course of several years.

- **[ambition gap] Codes for existing buildings**: These refer to standards requiring improvements to the building's envelope or systems in the event of significant works, whether they were part of an energy retrofit or not. Codes should be developed with respect to particular segments (e.g. commercial, multifamily residential, single homes) and should ensure that refurbishments are carried out to align the performance of existing buildings to their cost-effective potential. *Stakeholder feedback: There is agreement that few building retrofits are governed by energy codes or standards, and where they are available, they are typically voluntary.*

- **Building refurbishment**: Refurbishment includes ongoing works a building owner or manager may carry out on an existing building, without being so substantial it would quality as a retrofit. Existing buildings should be gradually refurbished to meet the performance standards of new buildings, and maintained to increase their lifetime. Tools to assess the most cost-effective set of measures and plan for their implementation should be developed in order to facilitate planning of works (i.e. to assess whether works should be done step by step or in a deep energy retrofit). Labelling of components, incentives, LCA and energy management are examples of tools that will enable effective maintenance and refurbishment of existing buildings.

- **[ambition gap] Building labelling**: Quantitative building energy labelling can be used to assess building envelope and system characteristics on a scale of less to more efficient. Labelling enables increased information sharing and awareness for consumers and investors, and should become widespread in existing buildings as well as new buildings, and should increasingly disclose the embodied and operational carbon of buildings with reference to a benchmark (see "Activity 4: Building operations"). *Stakeholder feedback: Consensus is that labelling is currently common in some countries, and could increase to about half by 2040.*

- **Building passports**: These can be used to track information about the building, its materials, systems, energy use, renovations, sources of potential savings and other real estate information to improve decision-making processes. Basic information includes floor plans, floor area schedules, activity information, past retrofit of refurbishment works, and monthly energy consumption and peak demand. *Stakeholder feedback: There is a general lack of knowledge on what building passports are but a strong view that more information on the building will support analysis and improvement.*

- **Incentives:** Financial and non-financial incentives such as increased scope or special permits can be significant enablers of the refurbishment and retrofit of existing buildings. *Stakeholder feedback: Few countries have incentives available to support low-energy building refurbishment of existing buildings.*

Box 9 • Regional examples of policy action for existing buildings

Singapore's Building and Construction Authority programmes for existing buildings

Singapore has several financial schemes in place for existing buildings to make them more energy-efficient. These include the Building Retrofit Energy Efficiency Financing (BREEF) Scheme and the Singapore Green Building Council-Building and Construction Authority (BCA) Zero Capital Partnership Scheme (ZCPS) aiming at both major and minor retrofits. A total of 150 million Singapore dollars has also been fully committed under the BCA Green Mark Incentive Scheme for Existing Building and Premises, which was to help more than 125 private existing building owners carry out energy-efficient retrofits including replacement of chiller plants and lighting.

While some of these schemes are purely financial, others such as ZCPS support small building owners with capital and technical expertise. According to the 2nd Green Building Masterplan 2009, Singapore is focusing on greening the existing building stock so at least 80% of the buildings (by gross floor area) are green by 2030.

The 3rd Green Building Masterplan in 2014 sought to accelerate the green building agenda through engaging building tenants and occupants more actively to drive behavioural changes to energy consumption and to address the well-being of the people.

The BCA also has in place a minimum environmental sustainability standard that applies to large buildings about to install or replace a cooling system.

Viet Nam's building code includes provisions for the retrofit of some buildings

The Viet Nam Energy Efficiency Building Code covers mandatory requirements for building envelopes and systems to design and construct/retrofit civil buildings to improve energy performance. The code is currently being revised for 2019-30.

Malaysia's climate-adapted building rating tool is applicable to new or existing buildings

The Green Building Index is the green rating tool used in Malaysia specifically designed for the tropical climate. It is applicable for both residential and non-residential buildings.

India: **Rating system for existing buildings**

The GRIHA rating for Existing Building is a voluntary rating system launched in 2017, and since then almost 300 buildings have been rated under this system. The registered buildings are evaluated on 11 criteria divided among site parameters, maintenance and operation, energy, water efficiency, human health and comfort, and social aspects. A pre-feasibility study of the building is conducted by GRIHA professionals after which the building is registered for detailed evaluation and rating. After submission of documents and due diligence, a final site visit is conducted and final rating is awarded to the building.

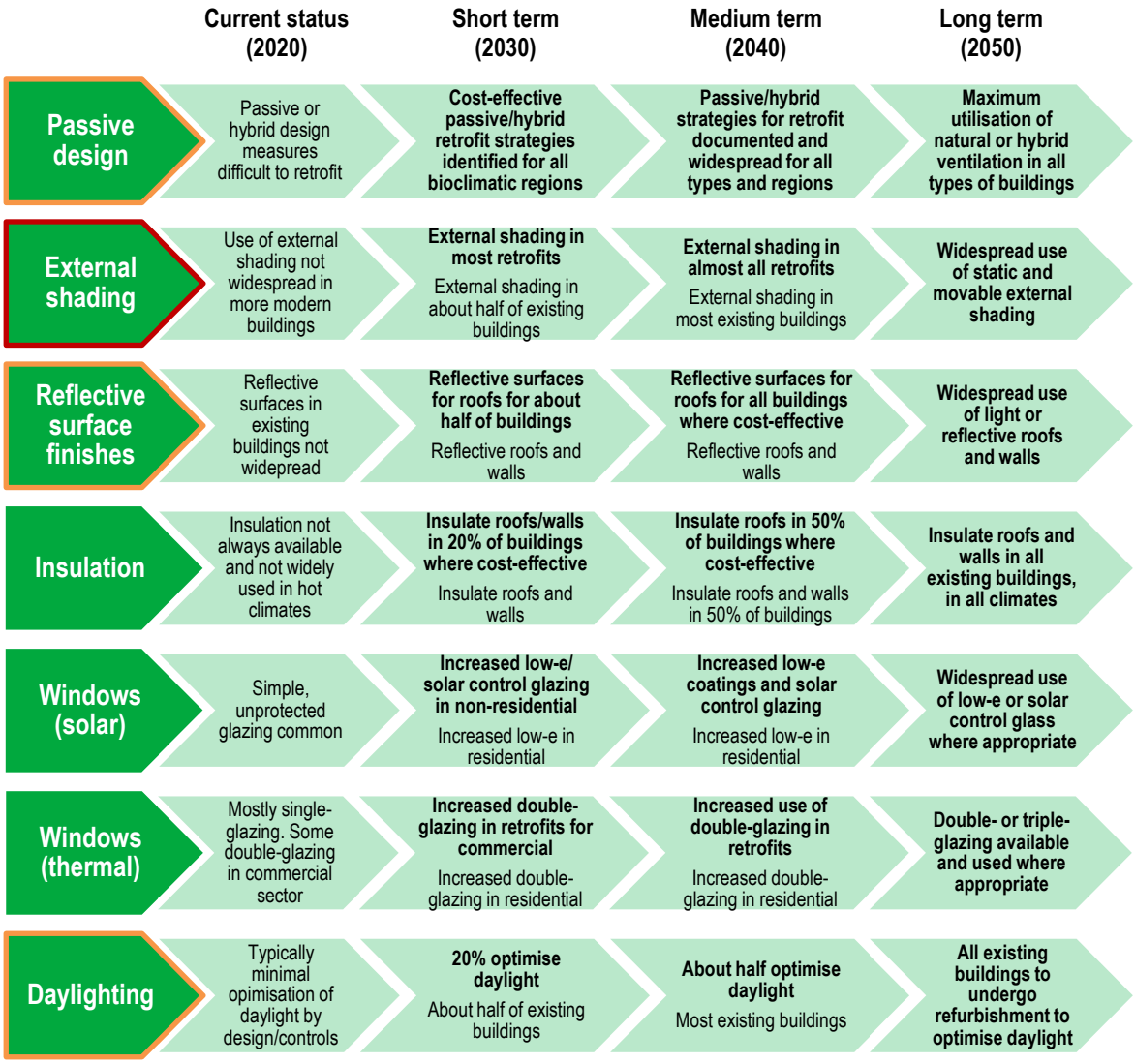
The IGBC Green Existing Building is another voluntary rating system which focuses on sustained performance of existing buildings with respect to green features. The IGBC rating system for existing buildings also uses criteria-based methodology to rate buildings.

Technology for sustainable existing buildings

Energy use and emissions from existing buildings are influenced by whether the building has undergone a building retrofit, the quality of that retrofit with respect to design, choice of technologies and materials, and what gradual improvements it has undergone over time.

Specific targets and timelines for sustainable existing building technologies are outlined below:

Figure 21 • Technology timelines for existing buildings in Asia



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- [data gap] **Passive design**: Strategies for the most cost-effective implementation of passive design measures such as upgrade of the building fabric, control of solar gains and ventilation, and daylight are highly dependent on the building type, how it will be used, and the macro- and micro-climate in which it is situated. Therefore, passive design strategies should be developed for specific bioclimatic regions and specific building types, and special considerations should be taken when applied to existing buildings. These locally adapted design guidelines specific to the retrofit of existing buildings can ensure that passive strategies can be optimised before relying on active systems. In combination with fans or active systems, hybrid solutions can provide significant energy savings when compared with a 100% active solution.

- [ambition gap] **External shading**: External shading in the form of horizontal, vertical, fixed or movable elements can be the most cost-effective method of blocking out solar radiation. Good shading can have the same effect on reducing the SHGC of windows as solar-performance glass. *Stakeholder feedback: External shading is not widely used in buildings currently and the progress to achieve its widespread adoption is seen as slow between now and 2050.*

- [data gap] **Reflective surface finishes**: Light-coloured surfaces or surfaces with reflective pigments reflect incoming solar radiation. Reflective surfaces are most effective on the largest surfaces exposed to the sun, which normally will be the roof. Painting external building surfaces can also be effective and relatively low-intrusion retrofit measures.

- **Insulation**: Insulation is one of the components of OTTV that should have specific targets for hot locations and cold locations. A material's insulation performance is determined by its thermal conductivity. "U-value" is also commonly used to express how much heat will transfer through a given thickness of a particular material, where the lower the U-value, the better the material is as an insulator. It is important to note that insulation is important in hot climates as well as in cold climates, and is most effective in the component of greatest surface area (i.e. the roof for low and flat buildings, walls for tall buildings). Note: the benefits of increased insulation should be assessed over a whole-life-cycle carbon assessment, given the high embodied carbon of most insulating materials. *Stakeholder feedback: There is consensus that although insulation is widely available, it is not common in retrofits, though it is used little today, and will increase to more than half by 2050.*

- **Windows (solar)**: The dominant source of heat transfer through windows is through solar radiation. This can be reduced with low-e and low-SHGC windows. Building design and advanced technologies can enable low solar heat gain during hot weather, while allowing visible light transmittance for natural daylighting; however, the most cost-effective way of avoiding excess solar gain is reducing the size of windows and providing shading. *Stakeholder feedback: There is consensus that low-e glazing is available and will become more widespread in retrofits by 2030.*

- **Windows (thermal)**: Heat transfer by conduction through windows can be reduced through a transition to double- or triple-pane windows, which have lower thermal transmittance, or U-value. When produced at scale, these types of windows can be highly cost-effective. These windows also provide noise protection and improve thermal comfort and can enable passive architecture and natural ventilation. Note: the benefits of double- or triple-pane glazing should be assessed through a cost-benefit analysis over the whole life cycle (for example using building simulation tools), also assessing the impact on embodied carbon, given the high materials and energy costs of glass manufacturing.

Stakeholder feedback: There is agreement that double-glazing will become mainstream by 2030.

- [data gap] **Daylighting**: Access to views and to daylight is essential for building occupant well-being, health and productivity. Building design should ensure that all spaces have access to natural light and views, and have glare-free, adequate daylight levels for large portions of the day through improved control. However, there is a need to optimise the ingress of natural light with the control of excessive solar radiation.

Box 10 •Regional examples of technologies for existing buildings

India's first certified heritage building

Bombay House, the headquarters of Tata Group, is the first heritage building to receive green certification in India under the existing building category in 2016. The 95-year-old building achieved 35% energy savings and 35% reduction in water consumption. Strategies implemented include use of paint mortar with a high solar reflective index on roofs, installation of better facility management systems, smart metering, measurement and verification systems and installation of solar PV (Tata Group, 2016)).

Passive house technology in Sri Lanka

The Star Innovation Centre in Katunayake, Sri Lanka, is a pioneer project in applying passive house technology to a tropical monsoon climate, and is a model for the garment industry thanks to its energy performance and worker comfort. Aside from being a renovation of an obsolete industrial building, its features include a highly insulated and airtight facade and highly efficient system with heat and enthalpy recovery. These measures have enabled it to reach an energy performance 75% better than a conventional industrial building (Construction21, 2016) and high worker comfort levels.

Finance for sustainable existing buildings

Finance tools particularly relevant to existing buildings may include:

- **Dedicated credit lines**: Funding delivered through banks for a specific purpose, which can prioritise sustainable buildings, construction or development projects. Dedicated credit lines to national or local governments can also be used to establish a revolving loan fund, which collects repaid loans for energy efficiency projects and reinvests them in additional energy efficiency projects.
- **Risk-sharing loan/loan guarantee/concessional loan**: Large organisation (such as a government, international bank or aid organisation) covering the risk of payment default, offering below-market interest rates, or offering longer grace periods for repayment to enable banks to fund a project with lower costs and therefore better loan terms.
- **Green bonds**: Bonds that can be used to bundle funding for projects with climate or environmental benefits.
- **Preferential tax**: Direct funding from the government to reduce or eliminate taxes for sustainable products and services.
- **Grants and rebates**: Direct funding to overcome upfront cost barriers, provided by a government, organisation or programme either through a competitive process (grants) or during or after the purchase of a sustainable product or service (rebates).
- **Energy performance/energy service contracts**: Contracts for services or delivered savings that typically are delivered by an energy services company (ESCO) and can include a range of energy efficiency services and products.

- **Green mortgages**: Prospective homeowners can solicit additional finance as part of their mortgage to install efficient features and technologies in their future homes.
- **Procurement purchase and lease**: The purchase or lease of sustainable products and services, e.g. green lease. Leasing enables the use of energy-efficient products on a rental basis to reduce a capital expenditure.
- **On-bill/tax repayment**: An approach where any recurring bill, such as utility bills, insurance bills or home improvement store bills, can collect small amounts of money over a long period of time to pay for energy efficiency purchases in smaller payments. An offshoot of on-bill finance, tax repayment is where the tax authority uses recurring tax payments as a means for collecting money over time. The most common of these is called property-assessed clean energy (PACE) and is able to use low-interest-loan repayments on the property tax bill until the purchase is paid in full.
- **Community finance and crowdfunding**: Collective funding from many people connected either locally or through a call for funding.

Capacity building for sustainable existing buildings

Information combined with capacity-building activities can increase overall awareness, improve the decision-making process and encourage more sustainable choices. Training for professionals working directly with the built environment can enable increased resources and capacity to deliver sustainable building retrofits.

The types of capacity-building activities relevant to existing buildings are mapped in Table 9, where the darker the colour, the higher the impact that capacity building type has for this activity.

Table 9 • Capacity building for existing buildings in Asia

Training within government	Training of professionals	Training of product/material manufacturers	Training of financiers and developers	Training of general public

Note: The darker the colour, the higher the impact that capacity building type has for this activity.

Details regarding the most critical capacity-building activities are explained below:

- **Training professionals**: Provide training programmes for service and product providers of buildings and construction (architects, engineers, contractors, building managers etc.) regarding how to undertake the most cost-effective retrofits in buildings, and how to comply with policies for existing buildings, programmes or incentives for the retrofit of buildings. Develop educational programmes including primary, secondary, vocational, university and adult education, to enable increased knowledge of sustainable buildings. Provide certification or accreditation for professionals in the sustainable construction sector.
- **Training the general public**: Develop information and awareness campaigns regarding the cost-effective building retrofit measures building owners or occupants can implement, including information and tools regarding how to access funding. Methods of increasing information to consumers include benchmarking programmes, certification programmes, building passports, mandatory disclosure, labels, educational resources, and information on utility and government programmes.

Further details regarding capacity-building activities are provided in the section Roadmap support: Enablers .

Multiple benefits for sustainable existing buildings

Many benefits can be achieved through sustainable existing buildings, and many of these are aligned with the SDGs. In particular, Goal 7 (affordable and clean energy), Goal 11 (sustainable cities and communities), Goal 12 (responsible consumption and production) and Goal 13 (climate action).

Some of these benefits are described in Table 10, although many of them require further analysis to quantify them:

Table 10 • Multiple benefits of existing buildings

	Environment
	• **Emissions reductions** – energy retrofits to existing buildings can deliver GHG reductions through lowered energy consumption. • **Air quality** – sustainable energy retrofits to existing buildings can reduce air pollution.
	Energy
	• **Energy savings** – energy retrofits to existing buildings deliver energy efficiency improvements. • **Energy security** – energy retrofits improve the energy-efficiency of existing buildings and put less strain on energy systems. • **Energy prices** – sustainable retrofits to existing buildings reduce energy demand and peak loads, lowering network infrastructure and system costs.
	Economy
	• **Economic performance** – energy retrofits to existing buildings can create employment for sustainability services and reduce building operation costs, freeing up resources to invest in other parts of the economy. • **Productivity** – retrofits to existing buildings can increase the productivity of occupants through improved thermal comfort, lighting and acoustic. • **Employment** – sustainable retrofits to existing buildings boost employment through new design and construction services for increased sustainability, including quality assurance and commissioning. • **Asset value** – sustainable retrofits to existing buildings make buildings more durable with lower operation and maintenance (O&M) costs.
	Society
	• **Poverty alleviation** – energy retrofits to existing buildings reduce building operation costs. • **Health and well-being** – retrofits to existing buildings can deliver increased thermal comfort, light, acoustic and indoor air quality, improving physical and mental health and well-being. • **Safety and security** – retrofits to existing buildings can include features such as building automation, sensors and lighting that can deter crime, improving safety and security.

Activity 4: Building operations

While the delivery of zero-emission, efficient and resilient new or renovated buildings is essential, it is equally important to ensure that buildings are operated efficiently. Behavioural and operational management influence the energy and emissions performance of a building.

Box 11 • Building operations in Asia: Trends and challenges

In order to reap the benefits, a sustainable building needs to be operated and maintained appropriately over the course of its lifetime. There are minimal policies regarding building O&M in the region. Adequate O&M enables not only energy savings but also increased quality of the internal environment, promoting health, well-being and productivity, and facilitates maintenance procedures, enabling a longer life of the buildings and its components.

With most of Southeast Asia's building energy consumption projected to be from appliances and air conditioning, user behaviour has a significant role in ensuring these are used efficiently (IEA, 2019g). Awareness of good user habits can be raised through capacity building and awareness campaigns, sustained with data describing the benefits of using energy more efficiently. This is particularly valid in the residential sector, where access to appliances and air conditioners is rising rapidly.

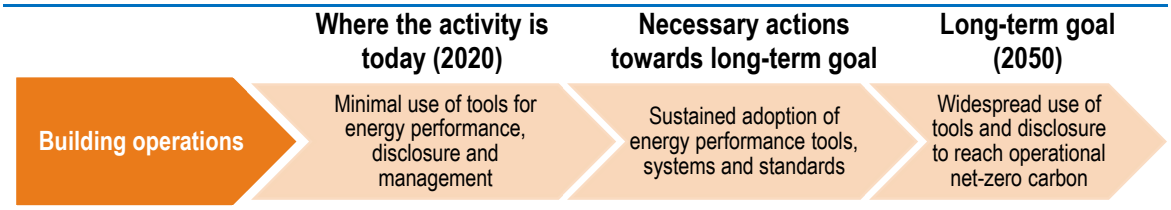
Within the commercial sector, advanced systems such as BMS and energy management systems (EMS) offer significant potential for reducing the energy consumed in buildings, as well as providing improved comfort and flexibility to the building users, and facilitate maintenance. Training professionals to install and operate these systems is required to unlock the potential savings within the existing building stock.

The data collected by EMS and BMS systems also have the potential to enhance the building data stock, contributing towards benchmarking, labelling, certification or monitoring of buildings policies, and enable energy management strategies such as those outlined in the ISO 50001 standard.

Buildings that are correctly operated and maintained have a longer life, essential for ensuring maximum efficiency of the building and its components.

Key actions for sustainable building operations

Figure 22 • Key actions for building operations in Asia



Key actions to improve energy management of buildings include:

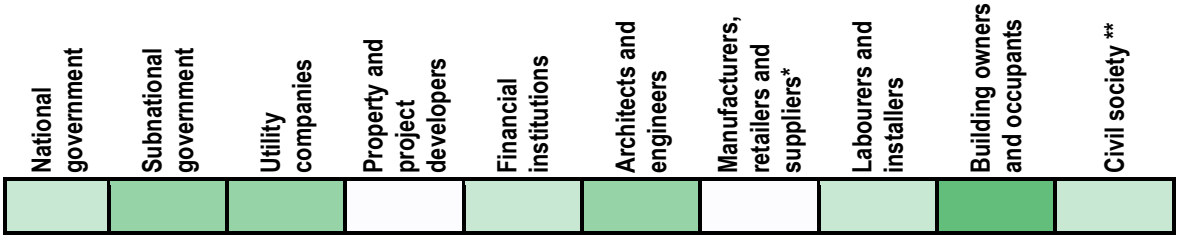
- **Rating tools and disclosure**. Develop national or subnational tools that enable the benchmarking and evaluation of a building's energy performance, develop disclosure schemes to enable comparison, and incentivise improved performance. Several countries in Asia have several rating tools; for example, the Green Mark in Singapore discloses energy use intensities. Expanding these programmes and strengthening their adoption and reporting will provide a basis for improvement.
- **Energy audits**. Promote the use of regular energy audits to identify inefficiencies in building operations. Across Asia, audits are not yet widely used and will provide a meaningful process for regular checking of system performance, particularly among large energy users.
- **EMS**. Provide tools and training for EMS and use energy management processes in all buildings, particularly non-residential buildings.
- **Smart controls**. The use of digital sensors and controls is critical to better managing building operations, such as temperature, lighting and ventilation systems controls. Installing energy metering and linking with building and EMS will also enable better management. Across the region, smart controls are being adopted into consumer appliances, such as air-conditioning systems.
- **Building passports**. Developing and supporting a system for regular information collection related to building system operations and energy use will improve the availability and support access to building information for current and subsequent owners and those who work with the building.

Stakeholders for sustainable building operations

In Asia, the key stakeholders for existing building operations include those who can influence existing buildings and those that can deliver the results of zero-emission, efficient and resilient buildings through operations. Additional stakeholders include those that can support the process through research, funding, training and making technologies available.

These stakeholders are mapped in Table 11, where the darker the colour, the higher the impact that stakeholder group has on the activity and the more essential they are to delivering the roadmap targets.

Table 11 • Stakeholder mapping for building operations in Asia



* of appliances and materials

** including academia, NGOs, research institutions, social networks and community associations.

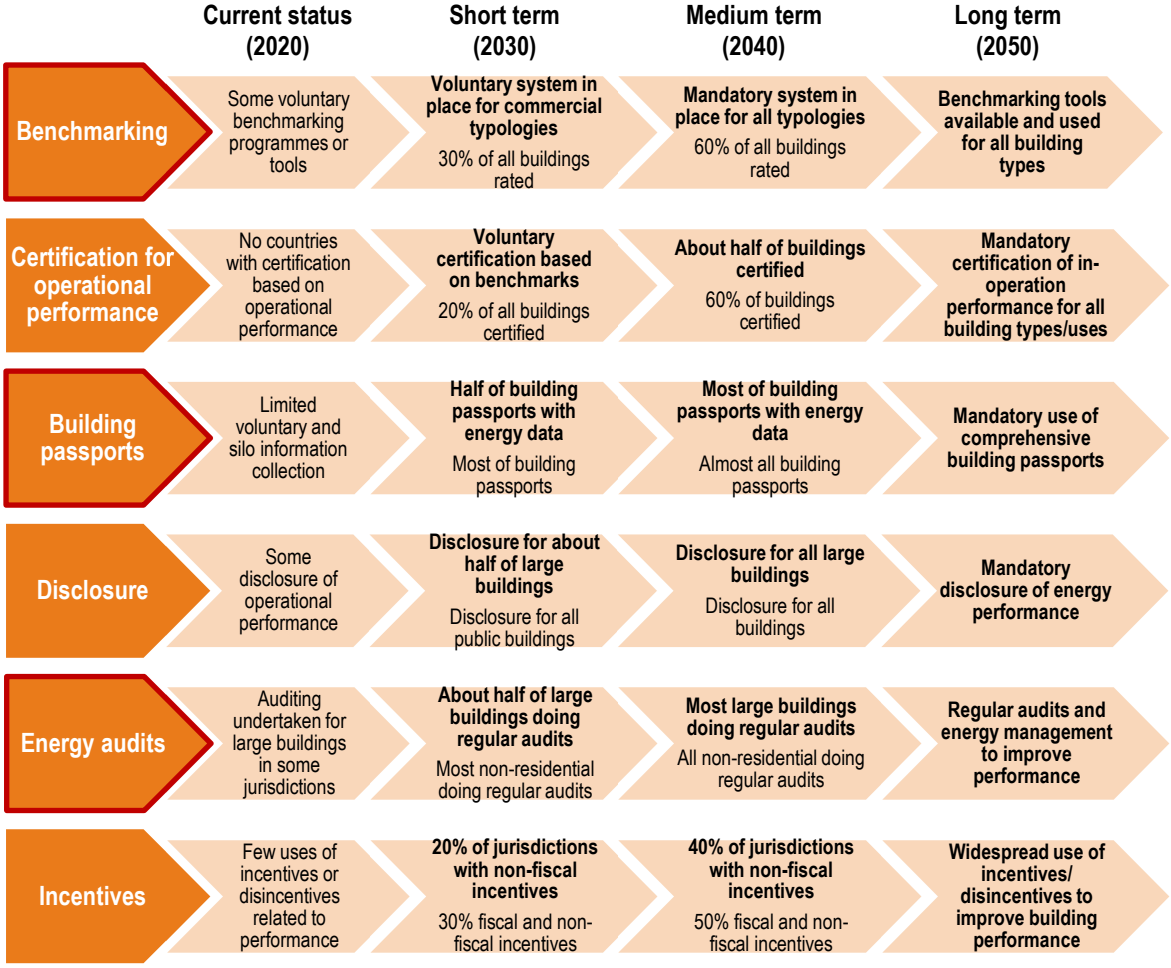
How to read: The darker the colour, the higher the impact that stakeholder group has on the activity and the more essential they are to delivering the roadmap targets.

Policy for sustainable building operations

Policies can be developed to promote highly efficient building operations.

Within the targets for sustainable building operations, the policy sub targets and timelines in Figure 23 offer more details:

Figure 23 • Policy timelines for building operations in Asia



Notes: The **proposed regional target** is in **bold**. Below that is the proposed accelerated target. A red border indicates an ambition gap for that target (more details below); an orange border indicates a gap in data or consensus (more details below).

Details on the policy targets for building operations are outlined below. For each item, in *italic* is a description of the consensus among the consulted local building experts regarding the evolution of the item between now and 2050. Where there was a significant gap between what was expected to be achievable by 2030, 2040 and 2050, the item is highlighted with a **red mark**, denoting that it is an area that will require particular action in its implementation. Where there was insufficient information, or insufficient agreement among responses, the item is highlighted with an **orange mark**, denoting that it is an area that requires additional information and consultation.

- **[ambition gap] Benchmarking**: By tracking performance and comparing that performance with other buildings, sustainability managers can make educated investment decisions to improve the overall performance of the building operations. Benchmarking can also support energy disclosure, certification and building passport goals. Robust data collection

is necessary to create locally appropriate benchmarks for comparison. *Stakeholder feedback: Few tools are currently used to assess operational energy performance in the region, and consensus is that adoption will be slow to about half of buildings by 2050.*

- **Certification for operational performance**: Building energy or sustainability certification and labelling can be used to disclose performance of the existing building and enforce performance requirements. The certification may be linked to benchmarking tools. The certificate or label can enable increased information sharing and documentation for consumers and financial decisions. The certification of operational performance can also allow the development of green lease agreements, where there is a binding agreement between the landlord and the tenant to enable the landlord to operate the building in accordance with its potential.
- **[ambition gap] Building passports**: Building passports can be used to track information about the building, materials, systems, energy use, renovations and other real estate information to improve decision-making processes with improved data that is tracked and stored. *Stakeholder feedback: There is a consensus that building information collected is limited, but an opportunity exists for passports to improve this to about half of buildings by 2050.*
- **Disclosure**: Mandatory disclosure of energy performance, certificates and/or benchmark rating of buildings can support improved data collection, decision-making and competition. *Stakeholder feedback: The region currently has voluntary disclosure that is used, and there is consensus that disclosure of performance will become widespread from 2040.*
- **[ambition gap] Energy audits**: Regular audits are powerful tools to assess opportunities for energy-saving measures, and should be performed regularly, particularly in buildings with high energy consumption. *Stakeholder feedback: The region does not widely use energy audits, and there is a consensus that audits will be slow to evolve to about half for all non-residential buildings by 2050.*
- **Incentives**: Non-financial incentives, such as expedited permits or increased floor area allowances, can encourage sustainable buildings operation. Financial incentives should be used to support the very best performing buildings. Both should be linked to building certification or disclosure policies. *Stakeholder feedback: There is consensus that incentives are generally not available but may be needed to support leading activities over time.*

Box 12 • Regional examples of policy action for building operations

Singapore's Building Control Act

The Building Control Act of Singapore requires owners of targeted buildings to submit energy efficiency audits of centralised building cooling systems every three years and information on building energy consumption annually. The regulations were implemented in stages in hotels, retail buildings, office buildings and mixed developments with gross floor area greater than 15 000 m^2 and has since expanded in 2017 to include more building types when owners install or replace their building cooling systems. Penalties can be imposed for non-compliance.

Voluntary rating systems for commercial buildings in India

India has initiated a voluntary star rating system for commercial buildings, including offices, hospitals, business process outsourcing (BPO) service centres and shopping malls. The Star Rating Program is based on the energy usage in the building over its area expressed in kWh/m^2/year. The buildings are rated on a scale from 1 to 5, with 5 being the most efficient. The label is valid for five years and acts as a symbol of recognition of energy efficiency.

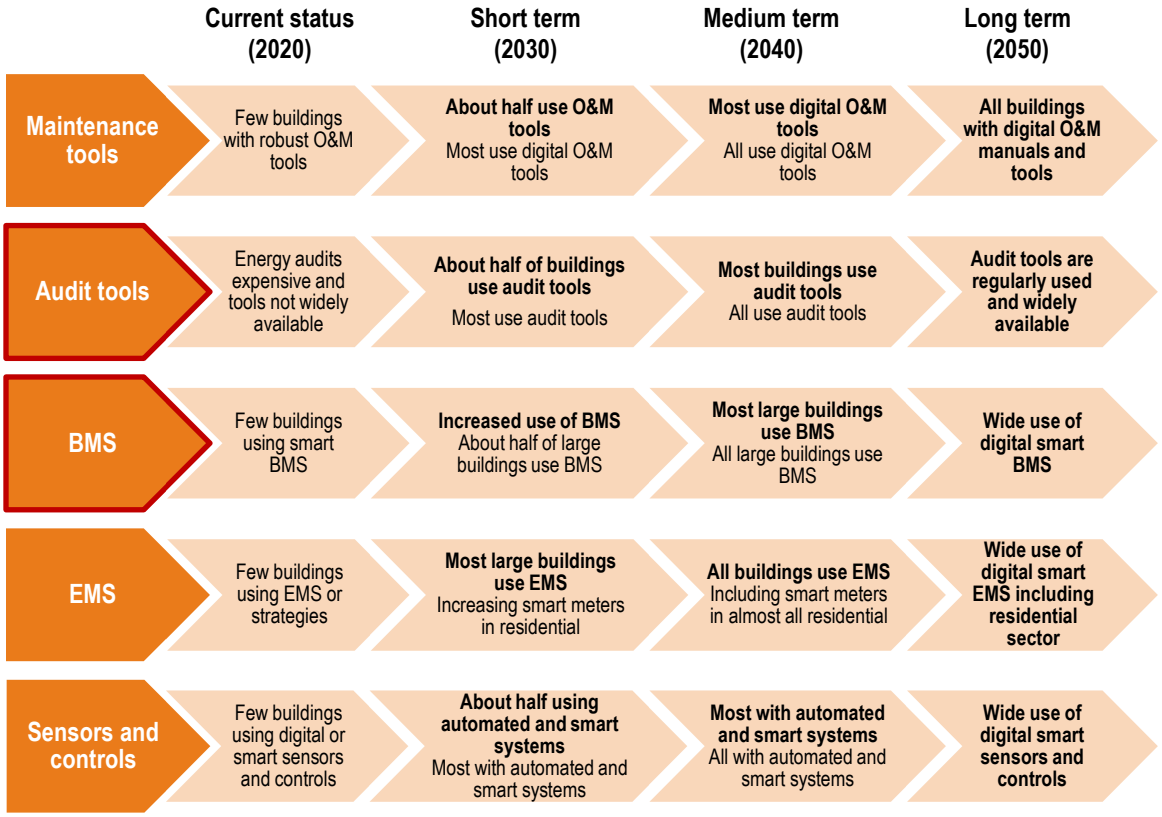
Penalty system for building owners in Japan

Japan has a penalty system in place for commercial and residential building owners who do not comply with the Energy Conservation Law for the buildings sector. According to the law, the owners of new buildings and buildings which undergo extensive retrofitting need to submit a report on the planned energy conservation measures before the construction or retrofit. After construction, the owner must submit periodic reports on the building's maintenance. If it is determined that the building is not energy-efficient, the local authority provides strategies for improvement. If the owner does not follow the instructions, the authority publicises the owner's name on list for non-compliance and the owner is obliged to pay a penalty.

Technology for sustainable building operations

Specific targets and timelines for sustainable building operation technologies are outlined in Figure 24:

Figure 24 • Technology timelines for building operations in Asia



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- **Maintenance tools**: O&M manuals can support timely and active maintenance of the building with schedules of specific periodic maintenance actions (e.g. cleaning or replacement of air intake filters). O&M manuals should increasingly be provided at the handover of a system after a retrofit or new installation and be actively used by building managers or operators. Active fault detection is a digital method for identifying maintenance needs and can increasingly be included in system installations and in BMS. *Stakeholder feedback: There is agreement that O&M tools will become more widely used by 2040 and widespread by 2050.*

- **[ambition gap] Audit tools**: Building energy and/or sustainability audits provide an opportunity to systematically check the optimisation of system configurations and to identify priority retrofit measures. Audit tools (e.g. software, sensors and thermal cameras) can reduce the cost to conduct an audit and improve the rate of annual building audits. *Stakeholder feedback: The use of audit tools is not widely used and there is a view that it will be slowly adopted by 2050.*

- **[ambition gap] BMS**: BMS can range from full-scale building software to simple controls that manage individual technologies within a building. The aim of a BMS is to improve its operation, automation and overall functionality, improving maintenance and comfort. Increasingly, digital tools are connecting multiple systems within a building with learning and fault detection to improve the overall management of the building system controls. BMS can also be key enablers of energy management strategies and systems. *Stakeholder feedback: The use of BMS is currently limited and there is agreement that BMS would be slowly adopted to only about half of buildings by 2050.*

- **EMS**: EMS enable monitoring of energy consumption of systems, components and/or the building as a whole to identify anomalies and understand energy consumption trends. A network of digital energy meters or sensors or a simple smart meter can form the basis of an EMS. The infrastructure for energy management can enable the adoption of an energy management strategy or protocol, such as those required to gain ISO 50001 certification.

- **Sensors and controls**: Sensors and controls are fundamental to smart maintenance, audit, energy management and building management. Control systems can range from fully centralised systems to simpler systems such as programmable thermostats. Sensors and controls are increasingly starting to incorporate machine learning to understand occupant preferences and behaviour and optimise system settings based on internal and external conditions. *Stakeholder feedback: There is agreement that adoption of smart sensors and controls could become common by 2040 and widespread in most buildings by 2050.*

Box 13 • Regional examples of technologies for building operations

Tokyo's "Energy-Saving Programme"

The Tokyo Energy-Saving Programme aims to transform Tokyo into a low-carbon city. The programme advises residents to examine their energy usage and its impact on the environment based on their lifestyle. Free energy audits are provided to low-income families. Municipal buildings are also included in the programme by installation of LED lighting and EMS to decrease energy usage by 25%.

The Yokohama Smart City Project aims to support the development of a smart grid system. To control the demand side, EMS are used. Business facilities utilise building energy management systems (BEMS) while residential buildings use the home energy management systems (HEMS) (USGBC, WorldGBC, C40 Cities, 2015).

An example of a LEED Silver building in Seoul, Korea

Seoul's Convention and Exhibition Centre is a multifunctional cultural complex that is LEED (Leadership in Energy and Environment Design) Silver certified. Besides energy-saving measures such as improving the building system and appliances, one of the most important strategies is the use of BEMS and building automation (USGBC, WorldGBC, C40 Cities, 2015).

Finance for sustainable building operations

Finance can enable increased action towards zero-emission, efficient and resilient building operations. Specific finance sub-targets and timelines are outlined below:

Finance tools relevant to building operations may include:

- **Dedicated credit lines**: Funding delivered through banks for a specific purpose, which can prioritise sustainable buildings, construction or development projects. Dedicated credit lines to national or local governments can also be used to establish a revolving loan fund, which collects repaid loans for energy efficiency projects and reinvests them in additional energy efficiency projects.
- **Risk-sharing loan/loan guarantee/concessional loan**: Large organisation (such as a government, international bank or aid organisation) covering the risk of payment default, offering below-market interest rates, or offering longer grace periods for repayment to enable banks to fund a project with lower costs and therefore better loan terms.
- **Preferential tax**: Direct funding from the government to reduce or eliminate taxes for sustainable products and services.
- **Grants and rebates**: Direct funding to overcome upfront cost barriers, provided by a government, organisation or programme either through a competitive process (grants) or during or after the purchase of a sustainable product or service (rebates).
- **Energy performance/energy service contracts**: Contracts for services or delivered savings that typically are delivered by an ESCO and can include a range of energy efficiency services and products.
- **Procurement purchase and lease**: The purchase or lease of sustainable products and services. Leasing enables the use of energy-efficient products on a rental basis to reduce a capital expenditure.

Capacity building for sustainable building operations

Information combined with capacity-building activities can increase overall awareness, improve the decision-making process and encourage more sustainable choices. Training for professionals working directly with the built environment can enable increased resources and capacity to deliver sustainable building operations.

The types of capacity-building activities relevant to building operations are mapped below, where the darker the colour, the higher the impact that capacity-building type has for this activity.

Table 12 • Capacity building for building operations in Asia

Training within government	Training of professionals	Training of product/material manufacturers	Training of financiers and developers	Training of general public

Note: The darker the colour, the higher the impact that capacity building type has for this activity.

Details regarding the most critical capacity-building activities are explained below:

- **Training professionals**: Provide training programmes for service and product providers of buildings operations (facilities managers, contractors, etc.) regarding how to undertake the most cost-effective operational measures in buildings, and how to comply with policies for existing buildings, programmes or incentives for the retrofit or efficient operation of

buildings. Develop educational programmes including primary, secondary, vocational, university and adult education, to enable increased knowledge of how to efficiently operate buildings. Provide certification or accreditation for professionals in the sector.

- **Training the general public**: Develop information and awareness campaigns regarding the cost-effective building operational measures building owners or occupants can implement, including information and tools regarding how to access funding. Methods of increasing information to consumers include benchmarking programmes, certification programmes, building passports, mandatory disclosure, labels, educational resources, and information on utility and government programmes.

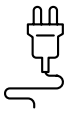
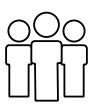
Further details regarding capacity-building activities are provided in the section Roadmap support: Enablers.

Multiple benefits of sustainable building operations

Many benefits can be achieved through sustainable building operations. Many of them are aligned with the SDGs, in particular with Goal 7 (affordable and clean energy), and Goal 13 (climate action).

Some of these benefits are described in Table 13, although many of them require further analysis to quantify them:

Table 13 • Multiple benefits of sustainable building operations

Environment	
	• **Emissions reductions** – more sustainable building operations deliver GHG reductions through lowered energy consumption. • **Air quality** – sustainable building operations reduce air pollution.
Energy	
	• **Energy savings** – sustainable building operations result in the more efficient use of building systems. • **Energy security** – sustainable building operations deliver reductions in energy use and put less strain on energy systems. • **Energy prices** – sustainable building operations reduce energy demand and peak loads, lowering network infrastructure and system costs.
Economy	
	• **Economic performance** – sustainable building operations reduce operating costs, freeing up resources to invest in other parts of the economy. • **Productivity** – sustainable building operations can enable increased thermal, light and acoustic comfort, which can result in improved productivity of occupants. • **Employment** – sustainable building operations can grow employment through operational services for increased sustainability.
Society	
	• **Poverty alleviation** – sustainable building operations result in lower costs. • **Health and well-being** - sustainable building operations can deliver increased physical and mental health through retro-commissioning and building management that increases thermal, light and acoustic comfort. • **Safety and security** – sustainable building operations can contribute to improved building management, operation and maintenance, avoiding for example, system failure.

Activity 5: Appliances and systems

Energy-consuming lighting, appliances and equipment systems commonly have a shorter lifetime than the buildings themselves and offer significant opportunity to reduce emissions in new and existing buildings. Aside from increasing appliances' efficiency, the human behavioural factors should also be considered: the manner in which users utilise appliances (e.g. operating air conditioners at temperature set points that are lower than required).

Box 14 • Appliances and systems in Asia: Trends and challenges

Across Asia, rapidly increasing incomes and living standards generate demand for appliances and equipment. South and Southeast Asian countries, for example, with high rates of cooling degree days and low average ownership rates (less than 20%), are expected to increase the market demand for air conditioners (IEA, 2018). Without strong action to ensure energy efficiency, the region could face a "lock-in" of inefficient appliances and equipment.

Asia is today home to over half of the world's air-conditioner stock, and 67% the world's appliances and plug load energy consumption, making it a key player in global energy use of appliances (IEA, 2019b). However, ownership per household remains low. As wealth increases, it is expected that the stock of air conditioners in Southeast Asia will grow from 40 million in 2017 to 300 million in 2040, with Indonesia accounting for half this growth (IEA, 2019e).

The average seasonal energy efficiency ratio (SEER) of air-conditioning units sold in the fastest-growing markets, such as China and India, is typically under 3.5 W/W. Yet products available in those same markets – often at comparable prices – can have SEERs that are 50–70% better. BAT is often twice as efficient, if not more (IEA, 2019b).

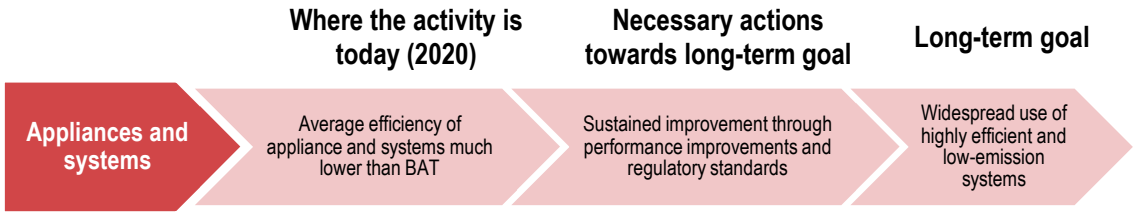
China has taken the lead in manufacturing the global stock of LED lighting, benefiting from strong financial subsidies and incentives from the government, and prices have fallen substantially to USD 3-5 per LED lamp (IEA, 2019b).

Fortunately, most electrical equipment in the region has mandatory or voluntary energy performance standards and labelling systems. Countries use the "letter" or "star" rating systems to enable consumers to choose energy-efficient appliances, and governments have already started phasing out inefficient equipment such as incandescent light bulbs or have laid out plans to do so.

The policies should also be regularly updated in terms of their strength. Despite the availability of more energy-efficient technologies, the market uptake is not high in comparison with less energy-efficient technologies. For example, more energy-efficient air conditioners in certain Southeast Asian markets are shown to be locally manufactured and available, as well as affordable, yet not widely purchased (IEA, 2019e). This builds a strong case for developing a roadmap of progressive strengthening of existing policies.

Key actions for sustainable appliances and systems

Figure 25 • Key actions for appliances and systems in Asia



Key actions to enable increased sustainability of systems in buildings include:

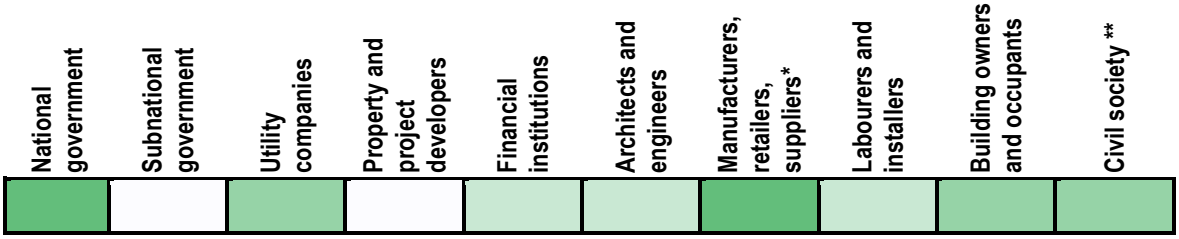
- **MEPS**. Develop, enforce and progressively improve standards that set product quality and performance requirements. MEPS are beginning to be more widely adopted across the region and for a greater number of system types. For example, India, Singapore and Viet Nam have adopted mandatory MEPS for lighting, air conditioning and a range of appliances, while countries such as Malaysia and Thailand have begun to adopt a mix of voluntary and mandatory MEPS for different systems. Going further and implementing mandatory standards for key energy services, such as lighting, air conditioning and white goods, will curb the growth in demand.
- **Enable investment in efficient systems**. Enable increasing use of sustainable products by increasing access to and use of finance to enable private investment. Investments in capacity building for manufacturers to produce more efficient appliances also helps support the effort to progressively increase the setting of MEPS. The rate of investment across Asia in clean and energy-efficient systems should be doubled from its current levels.
- **Governments lead by example**. Develop policies that ensure all government buildings invest in low-emission and efficient systems. Nationally or locally legislated procurement mechanisms for efficient appliances and systems help secure demand for manufacturers and help transform the market. Within the region, several countries are adopting higher standards in building construction and system performance across the public sector, including India and Indonesia.

Stakeholders for sustainable systems

In Asia, the key stakeholders for sustainable systems include those that can influence technologies and those that can deliver the results of zero-emission, efficient and resilient buildings through the adoption of sustainable appliances and systems. Additional stakeholders include those that can support the process through research, funding and training.

These stakeholders are mapped in Table 14, where the darker the colour, the higher the impact that stakeholder group has on the activity and the more essential it is to delivering the roadmap targets.

Table 14 • Stakeholder mapping for appliances and systems in Asia



* of appliances and materials (includes product testers and certifiers)

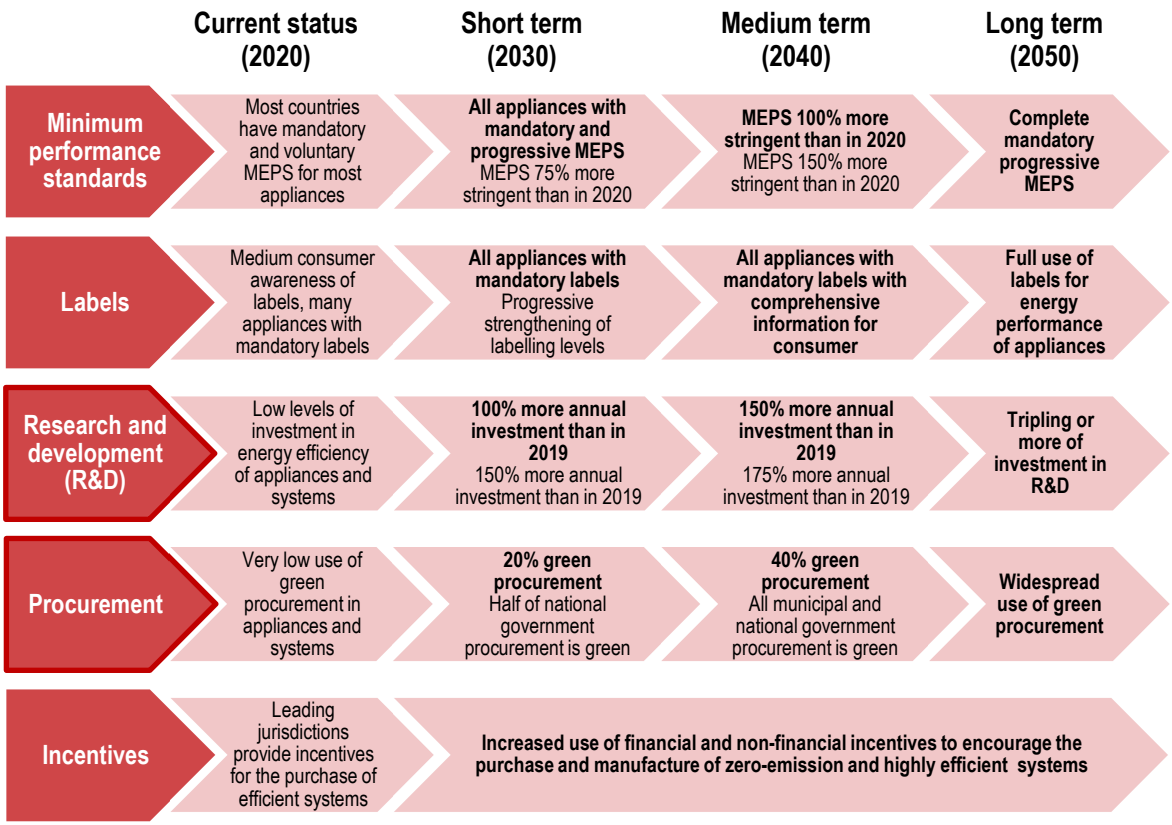
** including academia, NGOs, research institutions, social networks and community associations.

How to read: The darker the colour, the higher the impact that stakeholder group has on the activity and the more essential they are to delivering the roadmap targets.

Policy for sustainable systems

Appliances and systems policy can support zero-emission, efficient and resilient buildings goals by enabling market transformation that increases the availability of sustainable products. Within the targets for sustainable systems, the sub-targets and timelines in Figure 26 offer more details:

Figure 26 • Policy timelines for appliances and systems in Asia



Notes: The **proposed regional target** is in **bold**. Below that is the proposed accelerated target. A red border indicates an ambition gap for that target (more details below); an orange border indicates a gap in data or consensus (more details below).

Details on the policy targets for appliances and systems are outlined below. For each item, in *italic* is a description of the consensus among the consulted local building experts regarding the evolution of the item between now and 2050. Where there was a significant gap between what was expected to be achievable by 2030, 2040 and 2050, the item is highlighted with a **red mark**, denoting that it is an area that will require particular action in its implementation. Where there was insufficient information, or insufficient agreement among responses, the item is highlighted with an **orange mark**, denoting that it is an area that requires additional information and consultation.

- **Minimum performance standards**: Lighting, appliance and equipment products commonly have standards in many countries. These standards need to be expanded to all countries and strengthened for higher performance requirements. Testing protocols and enforcement of MEPS are essential for MEPS to work effectively. MEPS should also be in terms of the most adequate performance metric. There is a shift towards the use of a seasonal energy performance metric (such as the Seasonal Energy Efficiency Rating [SEER] or Cooling Seasonal Performance Factor [CSPF]) as has been undertaken by China and India and planned by the ASEAN member states through the ASEAN Standards Harmonization Initiative for Energy Efficiency (SHINE) programme. A seasonal metric is more appropriate

as it is more reflective of the appliance's actual consumption over the cooling season. This is a shift that other countries in the region should also follow. Minimum performance standards should also include limits regarding global warming potential of refrigerants and emissions of indoor air pollutants. *Stakeholder feedback: The use of MEPS is already regular across the region and there is widespread agreement that MEPS for all appliances could be implemented as soon as 2030.*

- **Labels**: Product labels on systems and appliances can provide information on the performance of the products including their embodied energy and carbon and their life-cycle energy and carbon performance. This kind of information enables consumers to make choices on a life-cycle basis, but also facilitates the implementation of incentives, MEPS and phase-out programmes. Labelling programmes can be supported by educational efforts to increase the capacity for people to make better design, purchase and operational decisions.
- **[ambition gap] R&D**: Increasing research funding can enable the invention of new products and services (e.g. solar thermal cooling, desiccant cooling, PV cooling) while also increasing the ability to get improved technologies to the market cost-effectively. *Stakeholder feedback: There is agreement that increasing R&D funding by 50% could be achieved in South and Southeast Asia by 2040.*
- **[ambition gap] Procurement**: Public and private entities can purchase sustainable products and services to support the effort to phase out the use of unsustainable products and services. This effort should be done by both public and private entities and can include bulk procurement or minimum performance specifications for procurement rules. The target in the timeline above refers to increasing shares of "green" procurement which is procurement based on minimum specifications such as minimum energy efficiency and/or other environmental standards. *Stakeholder feedback: There was agreement that sustainable procurement was not widespread and would be slowly adopted through 2040*.
- **Incentives**: Non-financial incentives, such as expedited product approvals, should be the priority to encourage sustainable systems. Financial incentives should be used to enable the market development and purchasing of the very best sustainable systems, while finance support, such as loan guarantees, should enable private investment in sustainable systems.

Box 15 • Regional examples of policy action for appliances and systems

India: **green procurement and appliance labels**

The Energy Efficiency Services Limited (EESL) Unnat Jyoti by Affordable LEDs for All (UJALA, meaning "light" in Hindi), is the world's largest domestic lighting replacement programme. By 2019, UJALA aims to replace 770 million old wasteful lamps with modern, efficient and longer-lasting LED lamps, without the need for any government subsidies. The bulk purchasing model strategy allowed EESL to buy LED lamps from manufacturers at a lower average price, from 800 rupees (INR) per LED bulb in 2012 to INR 200 in 2016. (EESL/IEA, 2016)

The BEE's Standard and Labelling Programme is another successful example of enabling the energy efficiency market for appliances. The main aim of this scheme is to provide consumers with informed choices about different appliances available on the market regarding energy and related cost savings. As of now there are 10 mandatory appliances and 23 voluntary appliances under the scheme. The scheme led to energy savings of 121 billion units from 2011 to 2018.

Southeast Asia: **Harmonisation of MEPS**

The ASEAN SHINE is aimed at promoting energy-efficient air conditioners and phasing out inefficient ones through harmonisation of test methods and energy efficiency standards and adoption of common MEPS.

Regional market integration initiatives such as this can provide manufacturers an additional certainty in the scale of demand of more efficient air conditioners and can thus help in lowering retail prices.

China and Japan: **Incentives for cleaner appliances**

In China, subsidies under the Air Pollution Prevention and Control Action Plan are helping reduce upfront installation and equipment costs of heat pumps. A similar scheme exists in Japan through its Energy Conservation Plan.

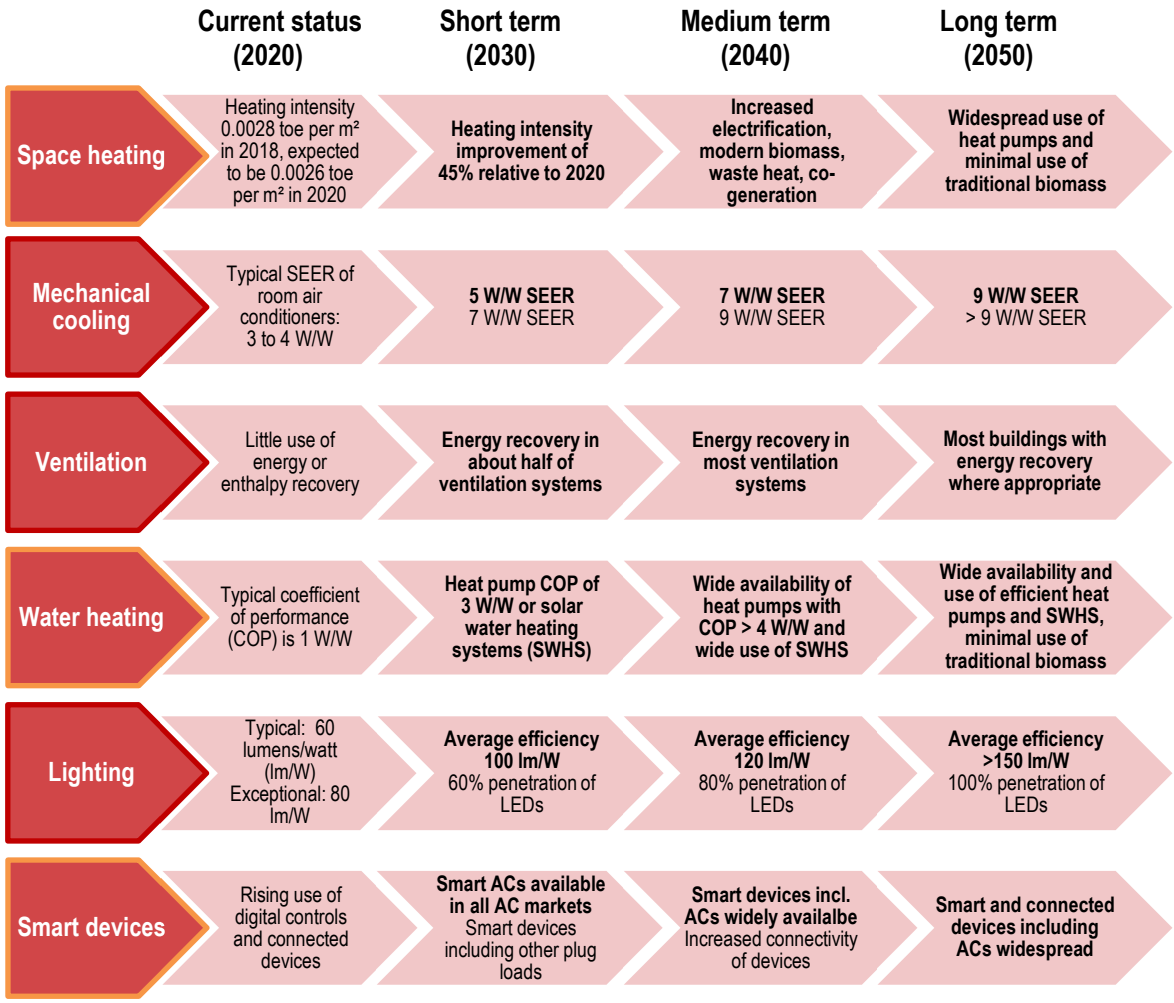
Kigali Amendment and alternative refrigerants

Having entered into force as of 1 January 2019, the Kigali Amendment adds to the Montreal Protocol the phase-down of the production and consumption of hydrofluorocarbons (HFCs). The amendment adds information on the global warming potential of HFCs, and selected hydrochlorofluorocarbons and chlorofluorocarbons, and provides equivalence values for CO_2 emissions. Importantly, there are exceptions for high-temperature countries, and limitations of importing and exporting goods with HFCs. The Kigali Cooling Efficiency Program supports developing countries in their transition to energy-efficient, climate-friendly and affordable cooling solutions.

Technology for sustainable systems

Specific targets and timelines for the sustainable system technologies are outlined in Figure 27:

Figure 27 • Technology timelines for appliances and systems in Asia



Notes: The **proposed regional target** is in **bold**. Below that is the proposed accelerated target. A red border indicates an ambition gap for that target (more details below); an orange border indicates a gap in data or consensus (more details below).

Details on the technology targets for appliances and systems are outlined below. For each item, in *italic* is a description of the consensus among the consulted local building experts regarding the evolution of the item between now and 2050. Where there was a significant gap between what was expected to be achievable by 2030, 2040 and 2050, the item is highlighted with a **red mark**, denoting that it is an area that will require particular action in its implementation. Where there was insufficient information, or insufficient agreement among responses, the item is highlighted with an **orange mark**, denoting that it is an area that requires additional information and consultation.

- **[data gap] Space heating**: Heating technology can enable more efficient delivery of space comfort through improved system efficiency. Heating systems also offer an opportunity for decarbonisation in the transition from fossil fuel heating systems to electricity or renewable energy heating systems. In Asia, heating intensities (in tonne of oil equivalent per m² floor area) are highest in OECD Pacific (including Japan and Korea) and China. The SDS will require improvements of up to 30% by 2030 (IEA, 2019b). Key technologies to achieve these reductions include heat pumps, modern biomass stoves and boilers, the phasing out of traditional biomass, and the use of waste heat or co-generation[11]. Efficient and renewable district heating systems also offer significant potential to reduce heating energy consumption intensity. *Stakeholder feedback: Very few data were obtained regarding the evolution of heating efficiencies and heating technologies.*

- **[ambition gap] Mechanical cooling**: While space cooling is the fastest-growing end use in buildings globally, cooling technology can enable more efficient delivery of thermal comfort through improved peak demand efficiency and SEER. Alongside appropriate design strategies that minimise the need for cooling, adoption of hybrid cooling methods, such as evaporative cooling, ventilative cooling and other "free cooling" that uses ground or water temperatures, can support the increased overall efficiency. Overall system efficiency will also increase with the use of variable speed drives and improved thermal distribution efficiency. Overall performance of the space cooling system is based on the efficiency of the cooling equipment and the thermal distribution system, such as ducts or pipes, to deliver the cooling within the building. *Stakeholder feedback: The outlook for improvement of the efficiency of air conditioners in the region appears to be alarmingly slow, with efficiencies expected to reach only 5 W/W to 6 W/W SEER by 2050.* The Future of Cooling in Southeast Asia (IEA, 2019e) *estimates that to accommodate the expected rise in cooling demand and stay on track for climate goals, global average efficiency of air conditioners in the region will have to reach over 9 W/W SEER by 2050; however, appliances with efficiency higher than 6 W/W are already available today, and in some markets are no more expensive than the average available. This gap suggests much work needs to be done in this area. Projects such as the Global Cooling Prize are essential to demonstrate that a rapid increase in efficiencies through new technology is possible* (Global Cooling Prize, 2019). *It is worth noting that equipment of SEER of 12 W/W is already available today in the United States* (IEA/KCEP, 2019).

- **[ambition gap] Ventilation**: To improve indoor air quality, controllable ventilation is essential. The three primary ventilation types include mechanical, natural and hybrid. To increase both the ventilation efficiency and energy retention efficiency, buildings can shift increasingly to hybrid ventilation, which uses natural ventilation when feasible and mechanical ventilation when natural ventilation is not effective. To further improve the efficiency, when in mechanical ventilation mode the system should include energy recovery ventilation technology to enable air exchange with minimal heat and humidity

[11] *Co-generation* refers to the combined production of heat and power.

transfer. Energy recovery ventilation efficiency will also need to improve from low-efficiency systems near 50% efficiency to high efficiency in the 80-90% efficiency range. *Stakeholder feedback: There is consensus that energy recovery will have a slow adoption, with few buildings expected to adopt it by 2050.*

- [data gap] **Water heating**: Available heating technologies can enable more sustainable and efficient delivery of hot water through the use of modern renewable energy sources and improved system efficiency. Efficient heat pumps, solar thermal water heaters, efficient modern biomass boilers and the use of waste heat and co-generation offer effective solutions for decarbonising water heating. Japan and China are currently the world's largest markets for heat pumps for water heating (IEA, 2019b). *Stakeholder feedback: Very few data were obtained regarding the evolution of water heating efficiencies and heating technologies.*

- [ambition gap] **Lighting**: Lighting technology can enable more efficient delivery of visual comfort through improved lumens per watt efficiency. Lighting technology developments in more efficient solid-state lighting are improving the quality of light, efficiency, maintenance and reducing costs. Daylight harvesting systems with intelligent controls, sensors and shading devices can also support the target for increased lumens per watt. Reaching efficiencies of 160 lm/W and a 40% penetration of LEDs in the residential sector by 2030 globally is needed to meet the SDS (IEA, 2019b). *Stakeholder feedback: There was strong consensus that lighting efficiencies would reach only 100-120 lm/W by 2050, which is far below what is needed in the SDS.*

- [data gap] **Smart devices**: Ongoing digitalisation of electric appliances is unveiling new opportunities to improve resource efficiency and flexibility, and allow consumers to manage their consumption through demand-side response. Appliances such as air conditioners and other devices should increasingly be equipped with the capacity for smart or connected control.

Beyond the items above with specific targets, the following system technologies can also support increased sustainability in buildings.

- **Appliances**: Large and small appliances both have opportunities for increased sustainability. Development in appliance efficiency is needed to counter the surge in appliance usage from rising wealth and ownership. The most significant gains have been in refrigerators, with specific targets noted above, where increased efficiency continues through variable speed compressors, improved insulation and heat pump technologies. Other appliances such as dishwashers, clothes washers and dryers, televisions, and digital appliances will need to become more efficient and reduce standby losses and connectivity energy use through the use of sensors, controls and automation to enable low-power modes, load balancing, demand response, and remote programming.

- **Energy storage**: Thermal energy storage for heating or cooling can enable load shifting, optimised heat transfer efficiency and integration with renewable energy, which will become ever more important with growing electrification and pressure on peak demand. Thermal energy storage systems can take the form of highly insulated water or refrigerant tanks, thermal mass or phase change materials. Current research is focused on reducing the costs, reliability and lifetime of high-density storage. Electrical storage in the form of batteries may also become important with the rise of decentralised renewable electricity generation and the interconnectivity of electric vehicles and buildings.

Box 16 • Regional examples of technologies for appliances and systems

Thailand: **Transitioning to natural refrigerants**

The Green Chillers Nationally Appropriate Mitigation Action (2016-20) promotes the use of natural refrigerants and energy-efficient measures in the refrigeration and air-conditioning sector in Thailand to reduce GHG emissions from the sector. Participating manufacturers are trained to handle natural refrigerants and provided with technical assistance in producing more efficient products. The project expects to save around 1 million million tonnes of CO_2 equivalent per year in the cooling sector by 2021 (NAMA Facility, 2017).

Internet of things (IoT) and smart appliances in China

China has long invested in smart appliances and systems as part of its development agenda for its IoT industry. The ready availability of domestic manufacturers for critical components of IoT-enabled appliances allowed it to expand its smart home market. Market size is estimated to reach USD 37 billion by 2025 (Renub Research, 2019)

India's bulk procurement of LED lightbulbs

India has demonstrated that it is possible to deploy LEDs rapidly on a large scale when the right financing and market mechanisms are in place: it has one of the largest LED markets in the world thanks to its national UJALA programme, which uses bulk procurement to offer bulbs that are 50% more efficient than other lamps available. More than 350 million LED lamps have been sold since 2015, and UJALA is aiming for 770 million by 2019.

Finance for sustainable appliances and systems

Finance can enable increased action towards zero-emission, efficient and resilient buildings through sustainable systems. Specific finance sub-targets and timelines are outlined below:

Financial tools particularly relevant to appliances and systems include:

- **Green bonds**: Bonds that can be used to bundle funding for projects with climate or environmental benefits.
- **Preferential tax**: Direct funding from the government to reduce or eliminate taxes for sustainable products and services.
- **Grants and rebates**: Direct funding to overcome upfront cost barriers, provided by a government, organisation or programme either through a competitive process (grants) or during or after the purchase of a sustainable product or service (rebates).
- **Energy performance/energy service contracts**: Contracts for services or delivered savings that typically are delivered by an ESCO and can include a range of energy efficiency services and products.
- **Green mortgages**: Prospective homeowners can solicit additional finance as part of their mortgage to install efficient features and technologies in their future homes.
- **Procurement purchase and lease**: The purchase or lease of sustainable products and services. Leasing enables the use of energy-efficient products on a rental basis to reduce a capital expenditure.
- **On-bill/tax repayment**: An approach where any recurring bill, such as utility bills, insurance bills or home improvement store bills, can collect small amounts of money over a long period of time to pay for energy efficiency purchases in smaller payments. An offshoot of on-bill finance, tax repayment is where the tax authority uses recurring tax payments as a means for collecting money over time. The most common of these is PACE, which is able to use low-interest-loan repayments on the property tax bill until the purchase is paid in full.

- **Community finance and crowdfunding**: Collective funding from a large number of people connected either locally or through a call for funding.

Capacity building for sustainable appliances and systems

Information combined with capacity-building activities can increase overall awareness, improve the decision-making process and encourage more sustainable choices. Training for professionals working directly with the built environment can enable increased resources and capacity to deliver sustainable systems.

The types of capacity-building activities relevant to appliances and systems are mapped in Table 15, where the darker the colour, the higher the impact that capacity building type has for this activity.

Table 15 • Capacity building for appliances and systems in Asia

Training within government	Training of professionals	Training of product/material manufacturers	Training of financiers and developers	Training of general public

Note: The darker the colour, the higher the impact that capacity building type has for this activity.

Details regarding the most critical capacity-building activities are explained below:

- **Training within government**: Provide training to central and local government regarding the implementation of MEPS and labelling systems, the development of testing protocols, and training on how to co-ordinate with other government stakeholders and industry and obtain their buy-in, as well as training on how to monitor and evaluate the success of policies.
- **Training of product/material manufacturers**: Provide training to industry on how to comply with MEPS and labelling policies, including support for leveraging the benefits of producing more efficient equipment.
- **Training of general public**: Develop information and awareness campaigns regarding the benefits of more efficient and more sustainable appliances, including information and tools regarding how to access funding. Methods of increasing information to consumers include benchmarking programmes, certification programmes, labels, educational resources, and information on utility and government programmes.

Further details regarding capacity-building activities are provided in the section Roadmap support: Enablers .

Multiple benefits of sustainable appliances systems

Many benefits can be achieved through sustainable systems. Many of them are aligned with the SDGs, in particular with Goal 7 (affordable and clean energy), and Goal 13 (climate action).

Some of these benefits are described in Table 16, although many of them require further analysis to quantify them:

Table 16 • Multiple benefits of sustainable building systems

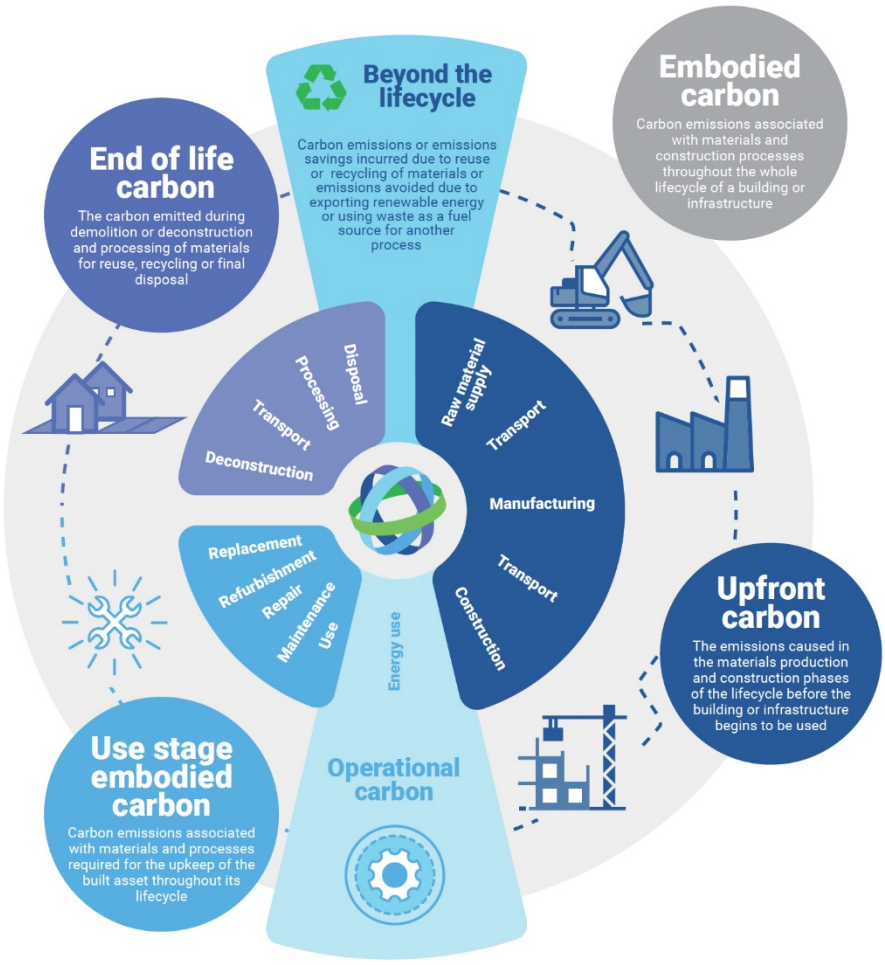
Environment
 • **Emissions reductions** – sustainable appliances and systems deliver GHG reductions through lowered energy consumption. • **Air quality** – sustainable appliances and systems reduce air pollution through lower on-site emissions and lowered energy consumption. • **Resource efficiency** – sustainable appliances and systems should have a longer lifetime therefore reducing the material demand in the production appliances and systems. Appliance sharing or mutualisation can also reduce production volume.
Energy
 • Energy savings – sustainable appliances and systems are more energy efficient. • Energy security – sustainable appliances and systems use less energy and put less strain on energy systems. • Energy prices – sustainable appliances and systems reduce energy demand and peak loads, which can lower network infrastructure and system costs.
Economy
 • **Productivity** – sustainable appliances and systems can increase the productivity of students and employees through improved thermal comfort, lighting and noise. • **Asset value** – sustainable appliances and systems can improve the asset value of buildings.
Society
 • **Poverty alleviation** – sustainable appliances and systems reduce building operation costs. • **Health and well-being** – sustainable appliances and systems deliver increased thermal comfort, light, noise and indoor air quality, improving physical and mental health and well-being. • **Safety and security** – sustainable appliances and systems can include features such as building automation, sensors and lighting, as well as features to improve and facilitate maintenance which can prevent system failure.

Activity 6: Materials

Construction activity in the buildings sector generates a major flow of materials in every country. The construction and demolition of buildings accounts for around one-third of global material consumption and waste generation. GHG emissions and energy consumption are linked to every phase of the life cycle of materials, from extraction or harvesting to manufacture, transport, construction, use and demolition. For instance, steel, cement bricks and non-certified wood (deforestation issue) are some of the major building product emitters of CO_2.

Embodied carbon is the sum impact of all the carbon emissions attributed to the materials throughout their life cycle (extracting from the ground, manufacturing, construction, maintenance and end of life/disposal), as shown in Figure 28.

Figure 28 • The WorldGBC's scope and definition of the building life cycle



Source: WorldGBC (2019), *Bringing embodied carbon upfront - Coordinated action for the building and construction sector to tackle embodied carbon.*

Currently, the carbon emissions associated with the extraction, manufacturing and construction of materials for buildings represents close to 11% of all global emissions. These emissions include energy- and process-related emissions (GlobalABC/IEA/UNEP, 2019).

The factors that influence embodied carbon include the construction technique, material demand, durability, origin (recycled versus virgin and location), composition, manufacturing processes, and reusability or recyclability.

Globally, cement and steel are two of the largest sources of building material-related CO_2 emissions. Total cement production is responsible for around 7% of global CO_2 emissions, with steel contributing 7-9% of the global total, of which around half can be attributed to buildings and construction (WorldGBC, 2019).

Reducing the embodied carbon of major building components such as cement and steel will be key to decarbonising construction. It is recognised that these sectors are among the hardest to decarbonise, therefore it will require concerted action along multiple dimensions – from lowering the demand of material, promoting switches to low-carbon materials, to maximising energy efficiency in manufacturing and switching away from carbon-intensive sources of energy (Energy Transitions Commission, 2018). There are also significant opportunities in developing systems to enable the reuse and recycling of construction materials.

Actions include engaging all stakeholders along the value chain, the provision of clear information and robust data on embodied carbon, promoting the implementation of EMS in industry, revision of building standards and codes, use of building certification systems, green public procurement and virgin material taxation, developing and enforcing regulations on embodied carbon levels, ensuring the incorporation of consideration to embodied carbon in policy and planning instruments, and decarbonisation of the energy system (IRP, 2020).

Box 17 • Materials in Asia: Trends and challenges

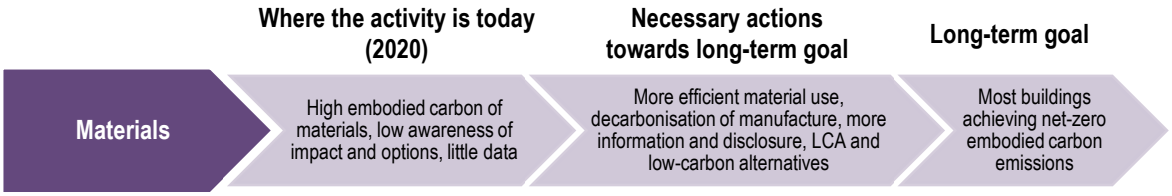
With the rapid development and emerging economies of the Asian countries, the demand for materials is rising. Increasing floor area has led to increased material demand, particularly in India and Southeast Asia. Asia's material demand is marked by strong diversities. In India, urbanisation and economic development are expected to greatly increase demand by mid-century compared with 2014 levels (steel production is expected to increase fivefold and cement more than threefold). On the contrary, in China, over that same period, production levels are expected to decrease as most infrastructure will have been built by then (steel production is expected to decrease by almost 30% and cement by 40%).

The Asia Pacific region is one of the largest producers and consumers of bricks in the world, with estimates of production over 1 trillion annually, which have traditionally been produced using topsoil from arable lands. Changes to these traditional manufacturing approaches requires rethinking production processes, labour and skills and availability of alternative higher-grade materials. It also requires a transformation of the market to provide better market access for both producers and consumers of bricks.

The International Resources Panel estimates that material efficiency strategies could reduce GHG emissions in the material cycle of residential buildings by 50 -70% in India and 80-100% in China by 2050 (IRP, 2020). Material efficiency strategies for homes include using less material by design, employing techniques such as prefabrication of modular construction (as demonstrated by China and Singapore), or encouraging lightweight design, material substitution, promoting more intensive use of buildings, enhanced end-of-life recovery and recycling of materials and components, and extension of building lifetimes.

Key actions for sustainable materials

Figure 29 • Key actions for materials in Asia



Key actions to enable increased sustainability of materials in buildings and buildings products include:

- **Collect data** on embodied carbon of building and construction materials; develop a database that can be accessed by all relevant stakeholders and that allows comparisons and calculations. Develop guidance on the use of methodologies and standards for making calculations and assessments.
- **Provide information and raise awareness**. Promote capacity on low-carbon materials and technologies (e.g. wood and earth constructions, innovative concrete) among professionals involved in the building design and construction process. Provide tools, training and capacity building; conduct or commission research into low-carbon materials and approaches. Carry out or commission case studies to convey the benefits of use of low-carbon materials and raise awareness.
- **Integrate considerations of embodied carbon in planning and building regulations**, require disclosure for all new construction and for large renovation projects, initiate low-carbon materials pilot projects, provide incentives to property and project developers.
- **Accelerate energy efficiency in manufacturing**. Develop measures to effectively speed up the implementation of energy efficiency in industries manufacturing building and construction materials. Promote energy management, develop best practice guides, and support the adoption of BATs. Include building material manufacturing industries as part of demand-side management efforts.
- **Stimulate markets for low-carbon products and materials**. Implement policies that enable improved design and purchasing decisions based on embodied carbon and energy. This could be achieved combining push levers, such as carbon pricing, tax incentives, subsidies and regulations on production of materials, with pull levers, such as public procurement and regulations on the construction sector. Develop policies that ensure all government buildings invest in low-carbon and efficient materials based on LCAs.
- **Require embodied carbon assessments** or LCAs to be undertaken on all new major and public investments, disclose portfolio and/or asset-level embodied carbon emissions, provide financial products to incentivise low-carbon projects and business models, provide preferential loans or mortgages to stimulate a market for low-carbon materials.
- **Reduce demand**. Develop approaches for lowering the demand for building and construction materials through design briefs and construction approaches that reduce the need for added materials. This in turn will help to **reduce extraction** of key natural resources, e.g. sand for building materials.
- **Reuse and recycle**. Develop strategies for repurposing of buildings when appropriate. Mandate plans and systems for collection and reuse/recycling of construction and demolition waste. Improve deconstruction processes including via the development of guidelines or protocols for deconstruction and selective sorting of waste.
- **Support the development of material reuse and recycling processes** for products and materials that can reduce the life-cycle embodied energy and emissions[12] and **increase the use of repurposed materials** in product manufacturing and in building and construction projects.
- **Promote circular economy**. Develop cradle-to-cradle life-cycle approaches in the buildings sector to enable a systemic, material-neutral and performance-based approach and business models. Integrate whole-life-cycle carbon thinking into planning and design processes.

[12] This has to be set cautiously as some materials can be reused only if the adequate processes are in place during the demolition phase (recovering un-hydrated cement can be achieved only if carefully designed processes are used to crush the concrete and separate the different constituent materials).

- **Support research, development and innovation**. Develop measures to enable and support basic and applied research into low-carbon materials and solutions; provide support to demonstration projects.
- **Decarbonise energy**. Shift investments towards renewable energy on an energy system level as well as on a manufacturing plant level.

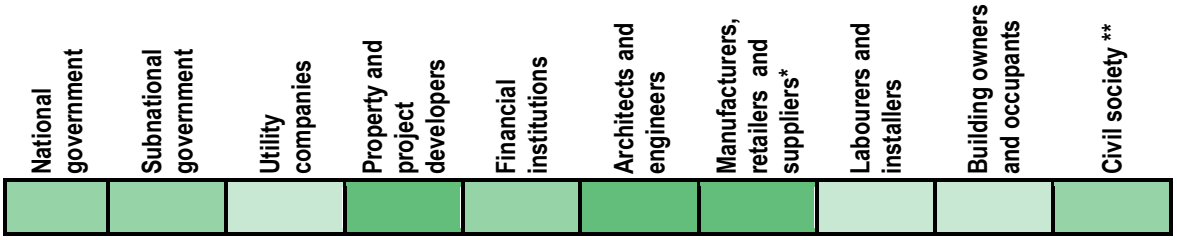
Stakeholders for sustainable materials

In Asia, the key stakeholders for sustainable materials include those that can influence the process of developing materials and those that can deliver the low-carbon, efficient and resilient buildings through the use of sustainable materials. Additional stakeholders include those that can support the process through research, funding and training.

While policies play a central role in accelerating a transition to zero embodied carbon, a range of different stakeholders can play an active part in the process. For instance, project and property developers can request disclosure on embodied carbon from material suppliers, and financial institutions can provide preferential financial products to projects that can demonstrate low embodied carbon. Manufacturing companies can start to voluntarily disclose information on embodied carbon of their products, and civil society organisations can play an important role in developing knowledge, raising awareness and providing capacity building.

These stakeholders are mapped in Table 17, where the darker the colour, the higher the impact that stakeholder group has on the activity and the more essential it is to delivering the roadmap targets.

Table 17 • Stakeholder mapping for materials in Asia



* of appliances and materials

** including academia, NGOs, research institutions, social networks and community associations.

How to read: The darker the colour, the higher the impact that stakeholder group has on the activity and the more essential they are to delivering the roadmap targets.

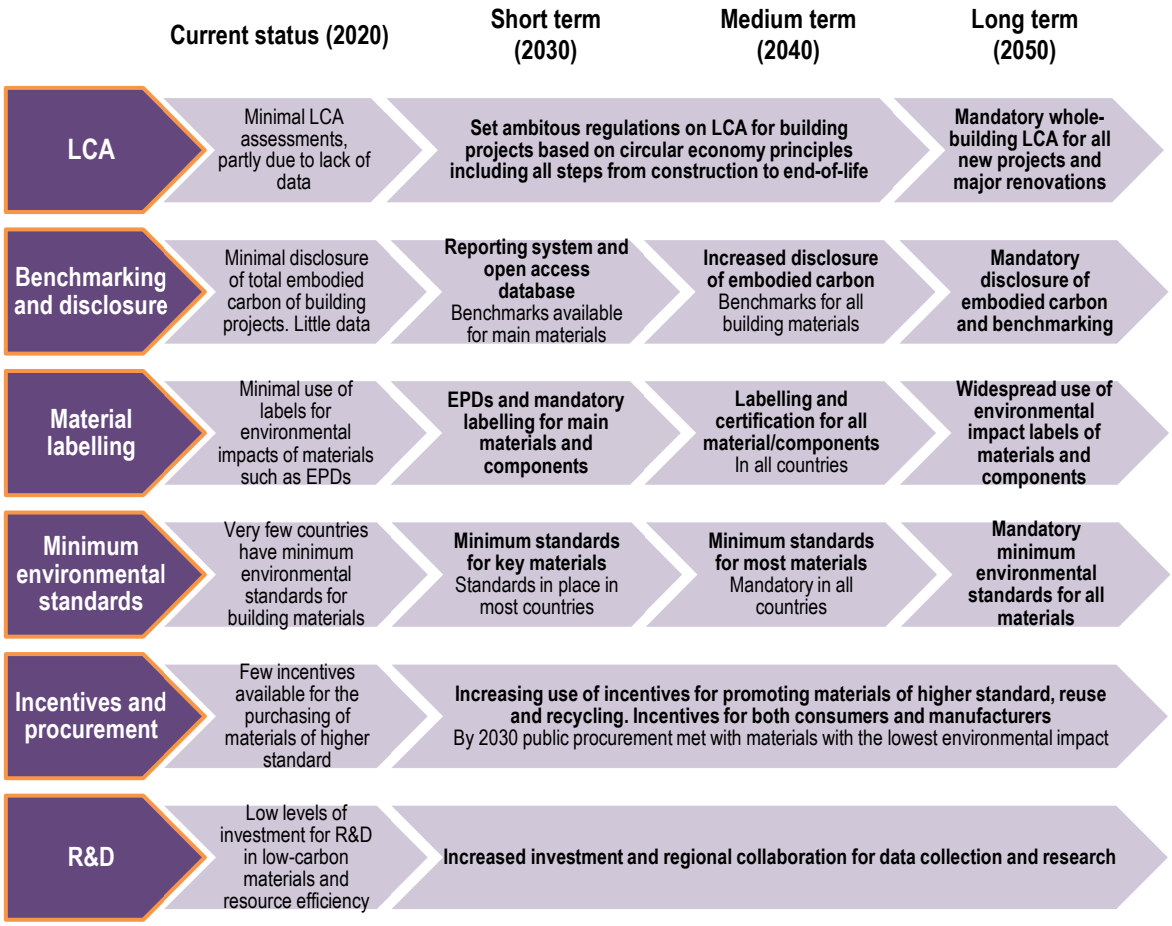
Policy for sustainable materials

Policy can support zero-emission, efficient and resilient buildings goals by enabling market transformation that increases the availability of sustainable products.

National, state and local governments are well positioned to spark action towards net-zero embodied carbon as they have the greatest powers to set standards and targets, implement legislation on materials and planning policies, invest in R&D, and deploy financial and fiscal measures that can shift the market. In particular, national governments may have the widest reach to facilitate value chain collaboration, stimulate market demand and integrate new holistic approaches such as circular principles in buildings and infrastructure.

Within the targets for sustainable materials, the sub-targets and timelines in Figure 30 offer more details:

Figure 30 • Policy timelines for materials in Asia



Notes: The **proposed regional target** is in **bold**. Below that is the proposed accelerated target. A red border indicates an ambition gap for that target (more details below); an orange border indicates a gap in data or consensus (more details below).

Details on the policy targets for materials are outlined below. For each item, in *italic* is a description of the consensus among the consulted local building experts regarding the evolution of the item between now and 2050. Where there was a significant gap between what was expected to be achievable by 2030, 2040 and 2050, the item is highlighted with a **red mark**, denoting that it is an area that will require particular action in its implementation. Where there was insufficient information, or insufficient agreement among responses, the item is highlighted with an **orange mark**, denoting that it is an area that requires additional information and consultation.

- [data gap] **LCA**: LCAs seek to quantify environmental impacts from material extraction and product manufacturing through to end of life. Decisions regarding the building use, design and choice of materials should consider the entire lifetime of the building and its components. National, regional or international databases containing information on the embodied energy and carbon of construction materials will be necessary to undertake comprehensive life-cycle impact analysis of design choices. All plans and designs should focus on lowering life-cycle impact. This means that all stages of projects should be considered and planned, from construction to demolition. In particular, plans on how waste will be reduced

and managed should be established as early as possible in projects. A waste management plan reduces the construction and demolition waste that are usually disposed in landfills or incinerated by providing options to recover, reuse or recycle the materials.

- [data gap] **Benchmarking and disclosure**: In order to monitor progress, understand best practices and facilitate better decisions at the design stage and in policy-making, benchmarking coupled with data disclosure will be of importance. Data disclosure requirements could build on experiences with material passports[13] and other initiatives such as the Carbon Disclosure Project.[14] Disclosure of the environmental impacts and efficiency levels of building projects should be developed in order to ensure a better enforcement of regulations.

- [data gap] **Material labelling**: Product labels on materials can provide information on the sustainability of the products, including their embodied energy and carbon and their life-cycle energy. EPDs and Health Product Declarations are some of the different voluntary labelling systems available currently supporting the information roll-out with educational efforts to increase the capacity for people to make better design, purchase and operational decisions.

- [data gap] **Minimum environmental standards**: The creation of EPDs for building and construction materials and products and their use in design is voluntary in most regions and countries. Some European countries, such as Finland, France and the Netherlands, are moving towards legislative adoption of LCA requirements for the construction industry, which is expected to be a catalyst for wider market penetration of EPDs (WorldGBC, 2019). The successive development and expansion of voluntary schemes towards mandatory minimum environmental standards for materials would effectively create markets for low-emission products. Testing protocols and standards for materials (including new materials) will have to be developed. Building codes, where in place, should include minimum environmental performance standards for materials to be used or via performance requirements encourage use of low-carbon materials. Stringency should be increased over time to continue to drive the market further towards low-carbon solutions.

- [data gap] **Incentives and procurement**: Financial incentives should be used to drive markets towards sustainable materials, while financial support, such as loan guarantees, should enable private investment in sustainable materials. Incentives should therefore address both sides: consumers and manufacturers of sustainable materials. These incentives will drive but also rely on procurement strategies: purchasing sustainable products and services should be done by both public and private entities and can include bulk procurement or minimum performance specifications for procurement rules. Public procurement should also include requirements for minimum recycled content and reusability or recyclability. Financial incentives should also be used to support new construction techniques that lower embodied carbon. Disincentives can also be used to penalise the use of particularly unsustainable materials, such as those responsible for unsustainable sand extraction.

- [data gap] **R&D**: Increasing research funding can enable the development of local materials production and supply chains, improved processes, practices and services while also increasing their economic competitiveness and their diffusion. Collective R&D efforts

[13] Material passports include data on all the materials that are included in a construction and provide information on characteristics and highlight the potential for reuse and recycling.
[14] Formerly known as the Carbon Disclosure Project, the CDP is a voluntary global system for investors, companies, cities, states and regions to manage their environmental impacts.

fostering cooperation and collaboration instead of competition can enable better allocation of resources, and a faster uptake of innovation as research outcomes are shared across the different countries.

Box 18 • Regional examples of policy action for materials

China green building materials action plan

In China, the Action Plan for Promoting the Production and Application of Green Building Materials, launched in 2015, presents a comprehensive framework for scaling up the use of more sustainable building materials in China. The action plan includes concrete targets on the percentage share of green building materials used by the construction industry, the energy intensity and the emissions. The action plan outlines a range of key action areas, from the strategic expansion of green manufacturing to the development of a green building materials label as well as accompanying assessment guidelines. Furthermore, MoHURD issued a National Standard for Building Emission Calculation in 2019. The new calculation standard factors in each phase of a building's life cycle, including the emissions intensity of the production and transportation of building materials as well as emissions during construction and demolition.

Promoting public procurement in Thailand

The Green Public Procurement Plan 2017-21 of Thailand encourages the use of green products in buildings by developing the green labelling scheme for building materials including insulation material, tiles, adhesives and paint, and also for electrical equipment including lights, air conditioners, refrigerators, and faucets and sanitary accessories.

India inserts materials into its National Building Code

The National Building Code (NBC) is a comprehensive national code by the Bureau of Indian Standards, which regulates the building construction activities across the country. The code serves as the modal code to be adopted by all agencies involved in building construction activities, whether private or public entities. The latest version of the code, NBC 2016, focuses on building construction materials. The NBC spells out materials which could be selected, easily dismantled and reused at the end of their life cycle. The NBC 2016 lays emphasis on broad selection of materials which could fulfil the sustainability criteria across extraction, production, transportation, fixing and ultimate disposal of materials.

India buildings material directory

An important step towards reducing the carbon footprint of buildings is ensuring access to information about the environmental performance of building materials. The BEE in India is working on resolving this by developing a material directory to help reduce buildings energy demand and emissions.

India voluntary certification standards

The main objective of the GreenPro certification standard for ready-mix cement (RMC) developed by the Confederation of Indian Industry (CII) is to help the producers adopt measures and to enhance the environmental performance of their products with the ultimate objective of reducing the GHG emissions of the RMC industry. The certification system evaluates the green features of RMC based on eight parameters, namely, product design, product performance, raw materials, manufacturing process, waste management, life-cycle approach, product stewardship and innovations (Confederation of Indian Industry, n.d.). Certification standards have also been developed by the CII for cement, high-performance glass, insulation products, construction blocks and construction chemicals.

Viet Nam green database and LOTUS building certification system

The LOTUS certification system for buildings was developed in 2010 specifically for the Vietnamese context by the Viet Nam Green Building Council (VGBC), covering most of the non-residential and residential building types. The system encourages the selection of materials and products that have low environmental impact and contribute towards better energy performance. The VGBC has also set up a resource directory for green building products and services.

India construction and demolition waste plans

The MoEF&CC in India enacted the Construction & Demolition Waste Management Rules 2016 on 29 March 2016 requiring that state governments prepare management policies within a year of notification; allocate sites for storage, processing and recycling; and procure and utilise 10-20% materials made from construction and

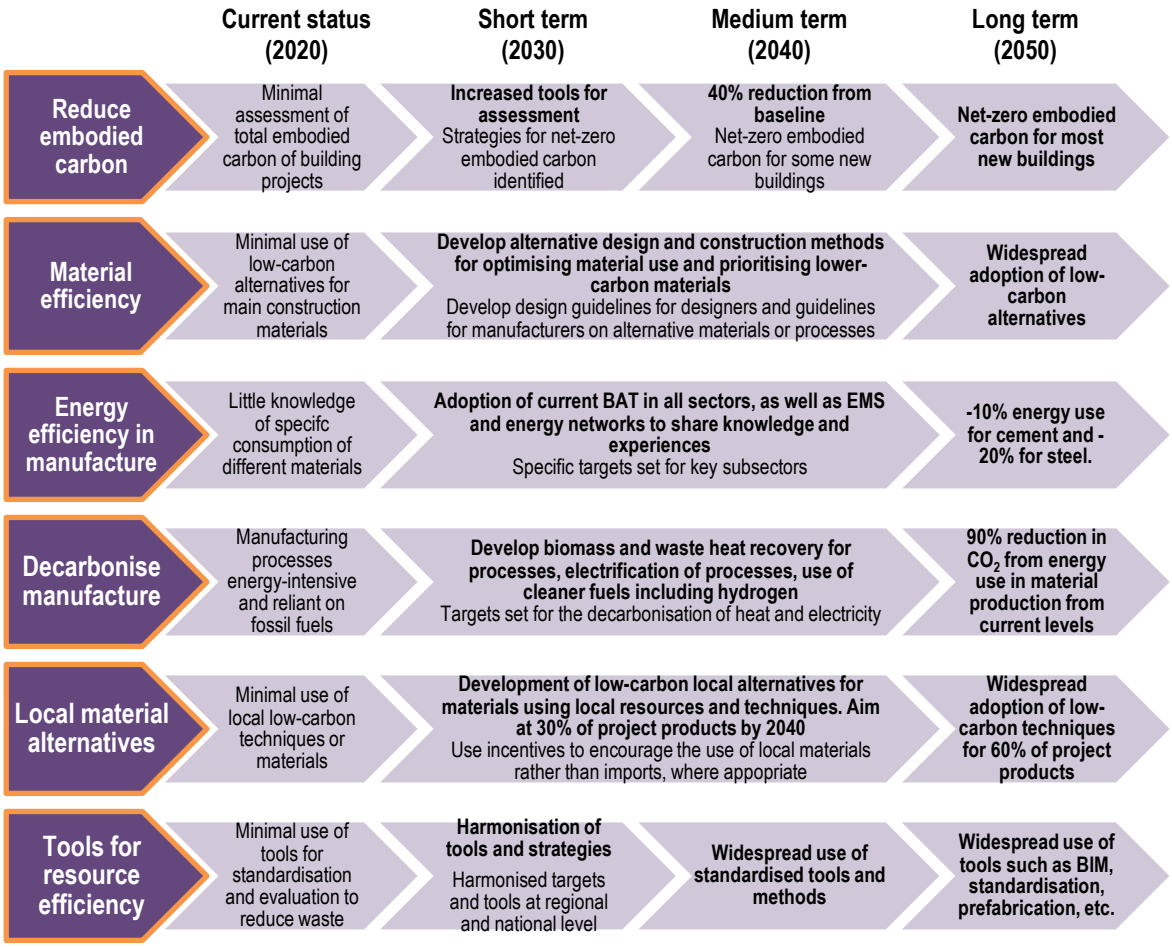
demolition waste in municipal and government contracts (MoEF&CC, 2016). Fines for illegal dumping are enforced in several cities.

The city of Ahmedabad in Gujarat has implemented an effective system for construction and demolition waste. The Ahmedabad Municipal Corporation has introduced aggregation and collection systems with public awareness and promotion of the new programme, which has resulted in segregation and collection of waste in predesignated areas. A commercial enterprise recycles the waste to produce non-structural building materials that are reused in public construction projects of Ahmedabad Municipal Corporation. Procurement incentives and policies have provided a boost to replicate this example in other cities in Gujarat.

Technology and strategy for sustainable materials

Specific technology targets and timelines for sustainable materials are outlined in Figure 31:

Figure 31 • Technology timelines for materials in Asia



Notes: The **proposed regional target** is in **bold**. Below that is the proposed accelerated target. A red border indicates an ambition gap for that target (more details below); an orange border indicates a gap in data or consensus (more details below).

Details on the technology targets for materials are outlined below. For each item, in *italic* is a description of the consensus among the consulted local building experts regarding the evolution of the item between now and 2050. Where there was a significant gap between what was expected to be achievable by 2030, 2040 and 2050, the item is highlighted with a **red mark**, denoting that it is an area that will require particular action in its implementation. Where there was insufficient information, or insufficient agreement among responses, the

item is highlighted with an **orange mark**, denoting that it is an area that requires additional information and consultation.

- [data gap] **Reduce embodied carbon**: Develop a strategy to decarbonise building materials and set targets for overall embodied carbon/energy of building projects and EPDs. This strategy will need to rely on comprehensive data collection efforts and the development or adaptation of standardised tools and benchmarks to assess embodied carbon and set performance targets of reduction over baseline over time. Specific targets should be set for the subsectors and in particular for the major materials used such as cement and steel, while promoting low-carbon and nature-based solutions for building materials.
- [data gap] **Material efficiency**: Reducing primary material demand through optimised design, optimised building techniques, the more intensive use of existing materials and the reuse of scrap material offer cost-effective measures to reduce embodied carbon of materials. In addition, low-carbon alternative materials already exist for several processes and usages (such as clinker substitutes for cement production or timber instead of steel in construction) and should be strongly encouraged and incentivised. Other examples include promoting concrete-steel composite construction, reducing cement content in concrete, lower clinker-to-cement ratio, etc. Precautionary steps would have to be taken in order to prevent negative effects (e.g. promoting the use of timber might increase demand for wood that would have to be met by sustainable harvesting).
- [data gap] **Energy efficiency in manufacture**: For all materials, indicators to monitor specific energy use for their production should be established, tracked and compared to BATs. This will allow manufacturers to set targets, and for the industry to develop minimum standards. Current BATs should be promoted across all sectors. Further measures to improve energy efficiency include making EMS (such as the ISO 50001) compulsory, promoting industry networks (to share best practices, identify energy efficiency potentials, set targets, etc.), and promoting access to and uptake of sustainable manufacturing technologies.
- [data gap] **Decarbonising manufacture**: The extensive use of renewable energy can be challenging in various industrial processes. However, by tracking the carbon embodied in materials, manufacturers will be encouraged to shift towards cleaner energy mixes (e.g. gas instead of coal, electrification of processes and use of hydrogen) and develop innovative solutions to maximise the use of waste heat and alternative sources of energy, or even waste material as fuel. These areas show great potential in sectors such as the cement or steel industry. There are at the moment few pilots to explore ways to decarbonise the heavy industry.[15] With the rate of increase in demand for materials in India, for instance, there could be an opportunity to develop a new industry based on the most advanced technology.
- [data gap] **Local materials alternatives**: Embodied carbon can be reduced by promoting the development of local low-carbon industry for the production of building materials where appropriate as determined by LCAs. This should be paired with new building methods, demonstration projects and case studies. Mapping of material flows and inventories of embodied carbon could support such a development.
- [data gap] **Tools for resource efficiency**: Measures should be taken to reduce manufacturing waste, develop materials and products that require fewer resources, and

[15] The Swedish initiative HYBRIT for steel manufacturing and the Norwegian project in Brevik for cement are to be noted as examples of pilots across the world trying to reach net-zero manufacturing.

develop projects that require fewer material inputs. At the design stage: reducing over-sizing and encouraging structural optimisation (such as lightweighting, drywall etc.) may enable using fewer materials to provide the same service, as could, for instance, the use of precast concrete material, the development of 3D printing, prefabrication, BIM, modularity of buildings, etc.

Box 19 •Regional examples of technologies for materials

India improves energy efficiency of cement manufacturing

The Perform Trade Achieve scheme, which sets specific energy consumption reduction targets in combination with a trading mechanism, has stimulated energy efficiency efforts in cement manufacturing. During the first cycle of the scheme, measures undertaken include increase of renewable energy, improved capacity utilisation and waste heat recovery. Measures resulted in energy savings of 1.48 Mtoe, corresponding to a CO_2 reduction of 4.34 million tonnes (BEE and GIZ, 2018).

Learning how to build with new materials in Indonesia

Switching towards materials with lower embodied carbon is key towards reducing the climate burden of buildings. There are several projects in Indonesia that use bamboo for construction. BambooU(niversity), located in Bali, provides training to professionals about the potential of bamboo as a green building material.

Alternative construction methods in Singapore

In Singapore, Design for Manufacturing and Assembly (DfMA) has been adopted for construction to achieve higher quality, productivity and sustainability. Through the DfMA approach, building components are designed and fabricated off-site in a controlled manufacturing environment, before being assembled on-site.

Prefabricated prefinished volumetric construction (PPVC) is one of the DfMA technologies that can lead to cleaner worksites by generating less overall construction waste on-site. It is a construction method whereby free-standing three-dimensional modules are completed with internal finishes, fixtures and fittings in an off-site fabrication facility, before they are delivered and installed on-site.

To ensure that the different PPVC systems being used at the mandated development sites are reliable and durable, the BCA has set up an acceptance framework consisting of building regulatory agencies as well as industry experts to ensure that the design and materials used are robust and can meet the minimum standards set through the Building Control (Buildability and Productivity) Regulations and the Code of Practice on Buildability 2017.

Finance for sustainable materials

Financial tools particularly relevant to sustainable materials may include:

- **Urban development funds**: Dedicated funding for urban development projects, which can prioritise sustainable urban development projects.
- **Infrastructure funds**: Dedicated funding for infrastructure projects, which can prioritise sustainable infrastructure projects.
- **Dedicated credit lines**: Funding delivered through banks for a specific purpose, which can prioritise sustainable buildings, construction or development projects. Dedicated credit lines to national or local governments can also be used to establish a revolving loan fund, which collects repaid loans for energy efficiency projects and reinvests them in additional energy efficiency projects.
- **Preferential tax**: Direct funding from the government to reduce or eliminate taxes for sustainable products and services.
- **Carbon pricing**: In order to facilitate the uptake of materials with low embodied carbon, a carbon price, could be implemented. This would be particularly relevant for cement and

steel. It would encourage materials efficiency, reuse and recycling; promote R&D for alternative solutions; and promote the decarbonisation of materials.

- **Grants and rebates**: Direct funding to overcome upfront cost barriers, provided by a government, organisation or programme either through a competitive process (grants) or during or after the purchase of a sustainable product or service (rebates).
- **Procurement purchase and lease**: The purchase or lease of sustainable products and services. Leasing enables the use of energy-efficient products on a rental basis to overcome high upfront costs or capital intensive investments.
- **Community finance and crowdfunding**: Collective funding from a large number of people connected either locally or through a call for funding.

Capacity building for sustainable materials

Information combined with capacity-building activities can increase overall awareness, improve the decision-making process and encourage more sustainable choices. Training for professionals working directly with the built environment can enable increased resources and capacity to deliver sustainable materials.

The types of capacity-building activities relevant to materials are mapped below, where the darker the colour, the higher the impact that capacity building type has for this activity.

Table 18 • Capacity building for materials in Asia

Training within government	Training of professionals	Training of product/material manufacturers	Training of financiers and developers	Training of general public

Note: The darker the colour, the higher the impact that capacity building type has for this activity.

Details regarding the most critical capacity-building activities are explained below:

- **Training within government**: Provide training to government about collecting data on embodied carbon of materials and building projects, and training on the development of an integrated policy portfolio towards zero-embodied-carbon buildings and construction. Provide training on how to develop information and assessment tools for project developers, designers and consumers such as embodied carbon disclosure, LCA, labelling and EPDs. These tools enable awareness among the building community and consumers, allowing them to make improved choices and promote lower-carbon design.
- **Training of professionals**: Provide training programmes for service and product providers of buildings and construction (architects, engineers, contractors, etc.) regarding how to design buildings with lower embodied life-cycle carbon in their materials. Include how to assess embodied carbon, how to use EPDs, how to perform LCAs, how to adapt design and construction techniques to lower embodied carbon in construction, how to correctly plan for end of life, and other circular design principles. This will require data collection and analysis to enable the creation of databases and resource platforms. Provide training on how to comply with policies such as labelling, EPDs, disclosure, LCA. Develop educational programmes including primary, secondary, vocational, university and adult education, to enable increased knowledge of sustainable building materials. Provide certification or accreditation for professionals in the sustainable construction sector.

- **Training of product/material manufacturers**: Provide training to industry regarding how to decrease the embodied carbon of materials and building, how to increase efficiency in manufacturing and construction processes, how to enhance the use of local materials, how to plan for end of life, how increase recycling and reuse, and other circular design principles. Provide training on how to comply with policies regarding labelling, EPDs, disclosure.

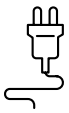
Further details regarding capacity-building activities are provided in the section Roadmap support: Enablers.

Multiple benefits of sustainable materials

Many benefits can be achieved through sustainable materials, and many of them are aligned to the SDGs. In particular, Goal 12 (responsible consumption and production) and Goal 13 (climate action).

The descriptions in Table 19 describe some of the benefits; however, further analysis should be conducted to quantify them.

Table 19 • Multiple benefits of sustainable materials

	Environment
	• **Emissions reductions** – sustainable materials reduce embodied carbon emissions in building and construction through lowered energy consumption in manufacturing. • **Air quality** – sustainable materials can improve indoor air quality because of lower pollutants, and can improve outdoor air quality through lowered combustion and cleaner manufacturing processes. • **Resource efficiency** – sustainable materials improve the resource efficiency of the manufacturing and construction of buildings through increased resource recovery, reuse and recycling across the supply chain.
	Energy
	• **Energy savings** – sustainable materials can deliver energy savings in both the manufacturing process and in the operation of buildings.
	Economy
	• **Economic performance** – sustainable materials can boost economic performance as the circular economy turns waste streams into new resource streams. • **Productivity -** sustainable materials will require the improvement of processes to meet targets for waste management and reuse. • **Economic security** – local sustainable materials would require the development of local industries to substitute imports.
	Society
	• **Poverty alleviation –** producing materials locally and training local populations can boost local economies. • **Health and well-being –** sustainable materials can be more natural, and less toxic.

Activity 7: Resilience

The concept of resilience has emerged in recent years as a crucial lens to look at the built environment. It promotes a holistic view of urban systems, embracing the interconnected and complex nature of cities' spatial configurations, physical assets, socio-economic functions and organisational structures. Resilience provides an overarching framework to classify the types of urban risks. Key factors influencing urban resilience include the "range and severity of hazards; the risk to lives and property; the vulnerability and exposure of human, social and environmental systems, and; the degree of preparedness of both physical and governance systems to any shock or stress" (United Nations Task Team on Habitat III, 2015). As recognised by Article 7 of the Paris Agreement, resilience is linked to both mitigation and adaptation.

Through the Sendai Framework for Disaster Risk Reduction, countries are engaged in taking measures to reduce disaster risks through seven global targets aimed at: reducing mortality; reducing risks to livelihoods, economic assets and infrastructure; and strengthening governance and local capacity to develop disaster risk reduction strategies, multi-hazard early warning systems and disaster risk information (UNISDR, 2015).

Climate and climate change affect construction in two principal ways: 1) as the climate changes, buildings' and building materials' design standards will have to change in order to withstand new weather conditions; and 2) as the pattern of natural disasters changes, a change in the demand for rebuilding and repair will occur. Therefore, the objective is to upgrade the durability and resilience of all buildings by gradually addressing the most critical infrastructures (e.g. those with social and economic relevance, such as hospitals, emergency facilities, schools, power plants, hazardous material facilities), followed by the most vulnerable buildings (e.g. in vulnerable communities) and the rest of the building stock.

Buildings and the housing stock in cities are among the greatest causes of death and destruction in most disasters (OECD, 2018). When buildings or homes collapse in earthquakes, floods, mudslides or landslides, they injure or kill many people. Collapsed buildings have accounted for nearly two-thirds of all natural disaster fatalities since 1980 (Munich RE, 2018).

Box 20 • What is a resilient city?

The Sendai Framework for Disaster Risk Reduction 2015-30 defines resilience as: "The ability of a city exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions" (UNISDR, 2015).

The discontinued 100 Resilient Cities Initiative of the Rockefeller Foundation laid out a City Resilience Framework: "The capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience".

In the context of cities, resilience has helped to bridge the gap between disaster risk reduction and climate change adaptation.

Box 21 • Resilience in Asia: Trends and challenges

The frequency of climate-related natural disasters has increased globally. Between 1980 and 2017 in Asia, there were over 1.2 million recorded fatalities and a loss of USD 1.69 trillion in assets due to natural disasters. Asset losses have increased over the past decades due not only to more frequent disasters, but also to the increasing value of public and private assets located in vulnerable locations (OECD, 2018).

An estimated 54% of Asia's population is currently living in low-lying coastal zones. The regional impact of climate-related changes, in particular sea-level rise, is highly uneven, with four out of five people affected living in Asia (UN-Habitat and UN-ESCAP, 2015). Today, the number of hot days in cities is twice as high as in the hinterland. By the end of the 21st century, this number could be 10 times higher (ADB, 2017). Asian cities are largely underprepared for natural disaster risks, especially as regards vulnerability and risk assessment practices. Comprehensive hazard assessment and mapping is not uniformly employed, which is particularly harmful for identifying and protecting low-income communities at risk. Land-use policies do not often consider resilience and disaster risk management, and urban growth has often developed uncontrolled, in risk-prone areas. In particular, the low-lying coastal cities of Southeast Asia are uniquely exposed to the effects of climate change (Bangkok, Ho Chi Minh City, Jakarta, Manila and Yangon).

According to the ADB, the number of people living in cities located in coastal areas and flood plains in Asia is projected to more than double between 2000 and 2060 (ADB, 2017). As cities grow, impermeable surfaces (asphalt and concrete) such as roads and pavement expand and exacerbate flood risk by covering land that could absorb water. Changing climate patterns have also affected some cities adversely with frequent storms leading to floods. Hence, storm-water management is an important aspect to be considered in Asian cities together with sewage, sanitation and solid waste management.

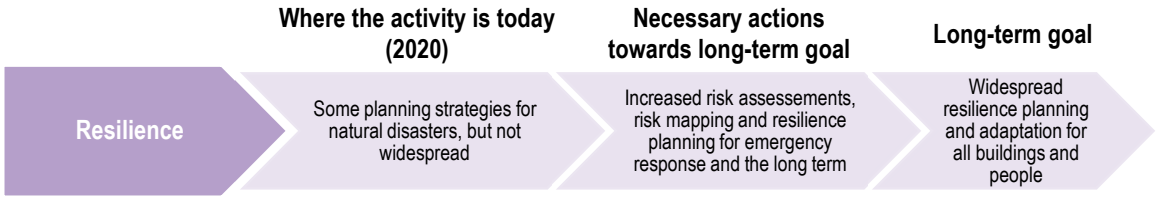
The increasing share of artificial surfaces, combined with rising population density, increasing transportation activity, and the growing use of air conditioners for space cooling, all lead to an increase in ambient waste heat in urban areas, or the UHI effect. Researchers from the Japanese National Institute for Environmental Studies analysed the long-term trends in surface temperature in several large Asian cities (including Bangkok, Jakarta, Manila, Osaka, Seoul, and Tokyo) and found an increase of UHI intensity by 0.6°C to 2°C during the 20th century, whereas the global mean temperature increased by only 0.7°C over the same period (Kataoka & al, 2009). These trends point to the importance of energy-efficient cooling in the region, which is a focus of recent IEA analyses (IEA, 2019e).

The UN-Habitat's global and regional reporting estimates more than 30% of the urban population of South Asia live in impoverished households, or "informal settlements" (UN-Habitat, 2016). The IPCC's Fifth Assessment highlighted that upgrading informal settlements is directly related to climate change adaptation. Most upgrading programmes have not explicitly pursued resilience to climate change explicitly but there are significant synergies between many aspects of slum upgrading, disaster risk reduction and climate change adaptation (Satterthwaite et al., 2018). In many cities in Asia, most of those at highest risk of flooding are low-income groups living in informal settlements.

Building resilience strategies into urban plans or building codes is limited in the region, with low awareness of the necessary tools and policies. To date, few countries, such as Japan, have national plans for climate change resilience. This does not always include the building sector. However, a number of cities, including Da Nang, Bangkok and Kampung, are enhancing their resilience strategies and institutional capabilities.

Key actions for resilience

Figure 32 • Key actions for resilience in Asia



Key actions to enable increased resilience of buildings include:

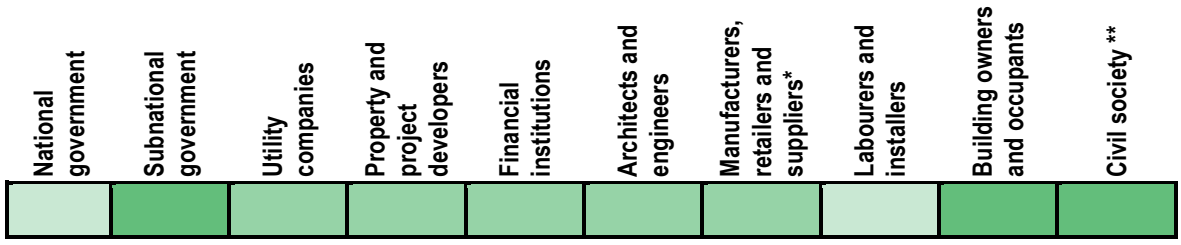
- **Urban planning and risk zoning**. Use data and information to document the potential risk exposure by location to enable effective urban planning through appropriate land-use planning, regulation, risk-sensitive investment and resource allocation decisions. This will lead to improved decision-making during the building and infrastructure design process. Identify areas of high growth and make planning frameworks that integrate climate risk assessment.
- **Wind- and seismic-resistant construction**. Implement policies and encourage best practice design and construction processes to enable buildings to be resistant to natural disasters and extreme weather events.
- **Storm-water management**. Require improved retention of storm water within properties to reduce the negative impact of water flowing to other properties and to surging waterways. Map areas of high growth and evaluate topography and rainfall risks and avoid development in those areas.
- **Thermal-resistant construction**. Implement policies and use best practice design to increase the resistance of buildings to extreme temperatures and moisture. Make use of appropriate ventilation strategies.
- **Develop integrated assessment**. Work across governments and stakeholders to develop assessment plans that help to ensure that resilience plans are holistic across jurisdictions and agencies.

Stakeholders for resilience

In Asia, the key stakeholders for resilience include those that can influence the ability to make technologies and design approaches available to increase resilience of buildings and those that can deliver the results of resilient buildings. Additional stakeholders include those that can support the process through research, funding and training, as well as emergency planners; ministries in charge of disaster recovery and resilience; state agencies with data, GIS or planning attributions; and energy and water planning offices.

These stakeholders are mapped below, where the darker the colour, the higher the impact that stakeholder group has on the activity and the more essential it is to delivering the roadmap targets.

Table 20 • Stakeholder mapping for resilience in Asia



* of appliances and materials

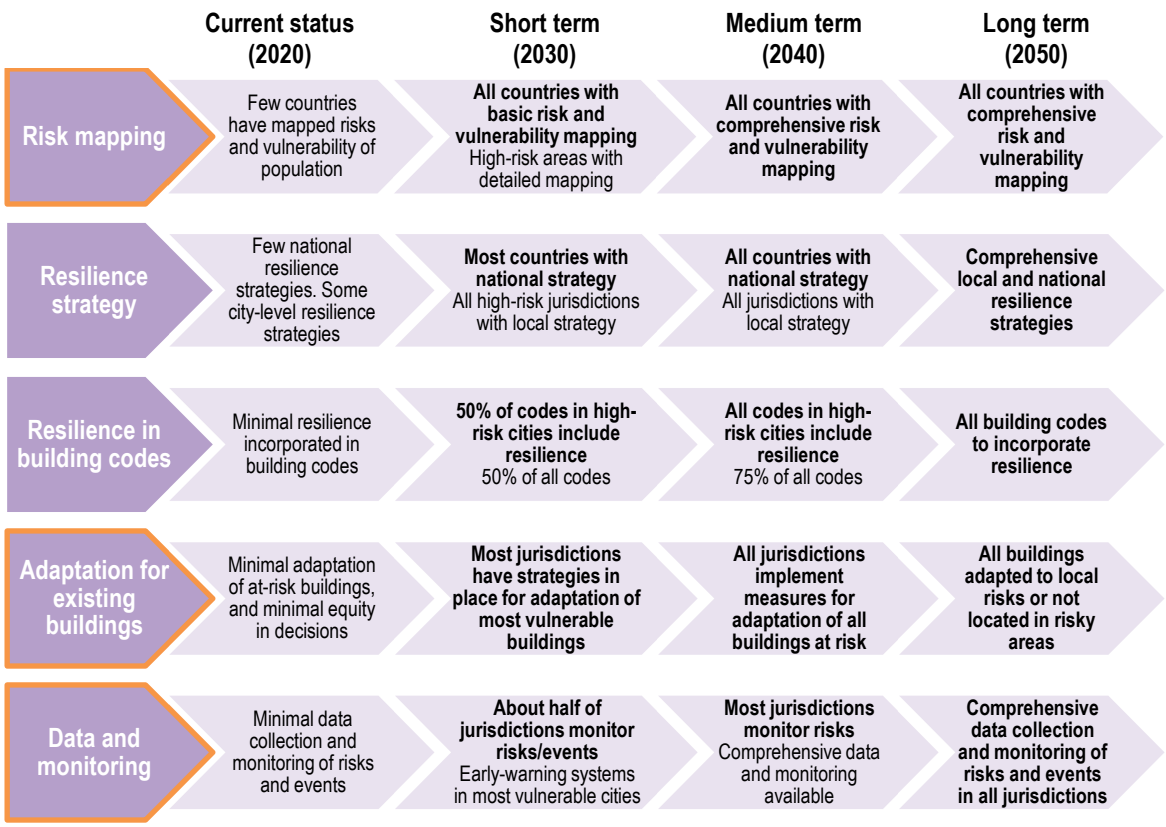
** including academia, NGOs, research institutions, social networks, and community associations.

How to read: The darker the colour, the higher the impact that stakeholder group has on the activity and the more essential they are to delivering the roadmap targets.

Policy for resilience

Within the targets for sustainable building resilience, the sub-targets and timelines in Figure 33 offer more details:

Figure 33 • Policy timelines for resilience in Asia



Notes: The **proposed regional target** is in **bold**. Below that is the proposed accelerated target. A red border indicates an ambition gap for that target (more details below); an orange border indicates a gap in data or consensus (more details below).

Details on the policy targets for resilience are outlined below. For each item, in *italic* is a description of the consensus among the consulted local building experts regarding the evolution of the item between now and 2050. Where there was a significant gap between what was expected to be achievable by 2030, 2040 and 2050, the item is highlighted with a **red mark**, denoting that it is an area that will require particular action in its implementation. Where there was insufficient information, or insufficient agreement among responses, the item is highlighted with an **orange mark**, denoting that it is an area that requires additional information and consultation.

- **[data gap] Risk mapping**: Gather and document data related to: land-use plans incorporating natural hazards (e.g. landslides, earthquakes) and climate-related risks (e.g. flooding, heatwaves), emergency plans, existing community plans, ordinances and codes, maps and data on geographic location of critical infrastructure systems or facilities, community utility needs (e.g., energy, water, and fuel use and generation), and climate preparedness plans.
- **Resilience strategy**: Develop a resilience strategy that identifies the list of policies and measures that can support increased resilience in an integrated manner, and addresses the potential for relocation and crisis plans for high-risk settlements. All countries should

develop national resilience strategies, and all jurisdictions should develop local resilience strategies. Resilience strategies should include planning for critical infrastructure (hospitals, schools, water supply, energy supply, etc.). Resilience strategies should also include requirements for "building back better" during reconstruction after a disaster. *Stakeholder feedback: There was consensus that very few jurisdictions have a resilience strategy in place, but that most would by 2050.*

- **Resilience in building codes**: Incorporate measures in building codes to increase structural and thermal resilience, including passive measures that enable occupants to use buildings when energy services are not available in an extreme weather event or natural disaster. This includes insulating, shading, load-bearing roofs, wind- and seismic-proof walls, and water drainage and storage systems. Given the long life of the massive building stock under development as Asia rapidly urbanises, there is a unique opportunity to integrate the dimension of resilience in energy building codes within the next decade to ensure that new buildings as well as existing buildings will be able to withstand long-term climate change effects. *Stakeholder feedback: There was consensus that very few building codes included elements of resilience, but that most would by 2050.*

- [data gap] **Adaptation programmes for existing buildings**: In many cities, existing buildings in informal settlements are located on sites at high risk from floods or landslides or from other risks (for instance on unstable landfills) because the risks make them unattractive to developers. Upgrading informal settlements is particularly challenging because of the high degree of informality, and in order to change communities as a whole, rather than isolated projects, commitment from national and local governments is particularly important. Community members should be involved in the planning and implementation of resilience urban upgrading schemes to enhance their understanding of risks and harness their knowledge of the environment in which they live.

- [data gap] **Data and monitoring**: The Sendai Framework includes a specific target dedicated to "Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to the people by 2030 (UNISDR, 2015). Several initiatives, often led by grassroots organisations, use a combination of satellite imagery and community-led surveys to map and analyse the profile of specific neighbourhoods and informal settlements. Settlements are mapped using plane table methods that show plot boundaries. Spatial and socio-economic data are then entered into a GIS database. Using this information, municipal governments and communities are able to prepare upgrading and resilience plans by widening roads, installing flood protection and building new infrastructure.

Box 22 • Regional examples of policy action for resilience

Incorporating resilience with informal settlements communities in Pune, India

Given the significant synergies between slum upgrading, disaster risk reduction and climate change adaptation (Satterthwaite et al., 2018), local governments in Asia are starting to engage slum communities in resilience planning. The NGO Shelter Associates works with slum communities in Pune, India, to use satellite imagery and field surveys to make the case for slum improvement based on detailed information. Very high resolution images from Google Earth are used to digitise slum boundaries and integrate socio-demographic information on households, dwellings and site characteristics from field surveys collected by slum residents. Settlements are mapped by professional agencies using plane table methods that show plot boundaries. Spatial and socio-economic data are then entered into a GIS database to prepare upgrading plans and maps (ELLA Learning Alliance on Climate Resilient Cities, 2014).

Working with slum residents, Shelter Associates called on the local government to initiate city plans to improve slum settlements by widening roads, installing flood protection, and building new infrastructure. As of 2014, the

Pune slum census covered over 100 000 households in over 200 informal settlement areas throughout the city. The residents gained skills in data collection and a better understanding of their collective community problems and resilience planning (ELLA Learning Alliance on Climate Resilient Cities, 2014).

Resilient Da Nang: **An exemplar of resilience planning**

Da Nang is a hub for transportation, services and tourism in central Viet Nam. The city is located along a long section of low-lying coastline where it is exposed to flooding and storms. For years, the city has been developing innovative models to enhance resilience to climate change, including early flood warning systems and improved urban planning (100 Resilient Cities, 2017). In 2017, Da Nang was the first city in Viet Nam to develop and release a resilience strategy. The second pillar of the strategy: "A prepared city" exemplifies a robust resilience planning framework. It includes key actions, such as: 1) expand floodwater drainage corridors and develop mechanisms to manage and restore these corridors; 2) assess flooding risk in new urbanised areas; 3) adjust the detailed plans which potentially impact drainage capacity; 4) restructure the urban design in high-flood-prone areas; 5) resettle residential areas which are located in flooding plains or frequently affected by flood; 6) develop the model of a flood-resilient community, and 12) develop monitoring and early-warning systems for flood risk (100 Resilient Cities, 2017).;

In line with its resilience strategy, the city has developed models that employ data to assess climate risk and shape its strategies, including early flood warning systems and hydrological data to project water levels and areas that would be affected. These projects use and collect data to monitor and predict potential risks, which informs urban planning as the city's various agencies and entities partner to build more resilient housing units. The city's Climate Change Co-ordination Office has worked with global insurance company Swiss Re to develop an open data-driven flood risk map to raise awareness of at-risk areas, and they are accessible to low-income households, whose houses are most prone to disasters (McKinsey Global Institute, 2018).

Co-ordinating resilience planning in the Bangkok Metropolitan Region

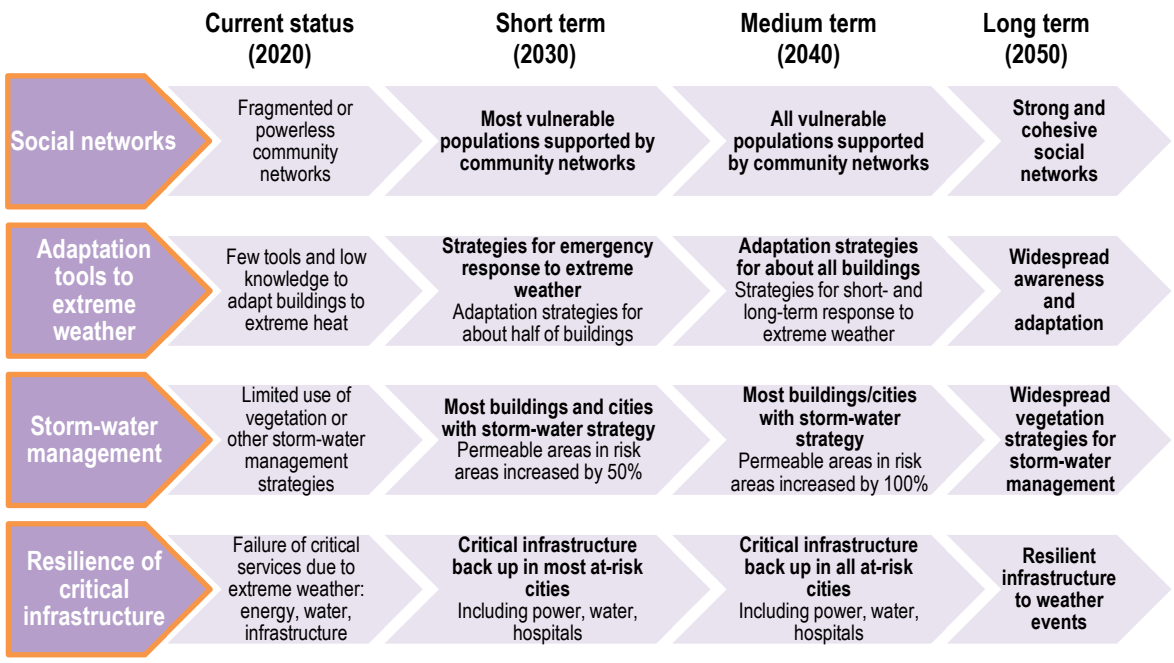
Bangkok, Thailand's capital, supports over 8 million people in the city, and over 14 million in its metropolitan area. The Bangkok Metropolitan Region is highly exposed and vulnerable to floods caused by seasonal storms. As the city rapidly urbanises, it is facing increasingly extreme weather patterns and subsidence, sinking up to two centimetres per year. Already, its major river system, the Chao Praya, has become more prone to flooding, and the World Bank estimates that 40% of the city could be inundated by 2030 (100 Resilient Cities, 2018). Once known as the Venice of the East, the city of Bangkok still has a number of canals that are used for transportation and drainage. However, the canals often have reduced functionality due to excessive garbage dumping, particularly by the communities residing by the canals (100 Resilient Cities, 2018).

In 2018, Bangkok launched its resilience strategy along three strategic action areas focusing on increasing quality of life, reducing risk and increasing adaptation, and driving a strong and competitive economy (100 Resilient Cities, 2018). Bangkok's Disaster Risk Management framework evidences the need to align "hard" investments in flood-resilient urban infrastructure with land-use planning and zoning policies as well as with "soft" instruments at the metropolitan scale. For example, Bangkok's Comprehensive Plan 2014-2018 provides tools to enhance flood resilience, such as the FAR Bonus System; minimum open space ratio; setback along rivers, canals and main roads; and control of building heights and sizes. However, these tools have been adopted only by the Bangkok Metropolitan Authority, whereas they could benefit the metropolitan region as a whole (OECD, 2018).

Technology for resilience

Technologies and strategies key to improve the resilience of the built environment are outlined in the timelines in Figure 34:

Figure 34 • Technology timelines for resilience in Asia



Notes: The **proposed regional target** is in **bold**. Below that is the proposed accelerated target. A red border indicates an ambition gap for that target (more details below); an orange border indicates a gap in data or consensus (more details below).

Details on the technology targets for resilience are outlined below. For each item, in *italic* is a description of the consensus among the consulted local building experts regarding the evolution of the item between now and 2050. Where there was a significant gap between what was expected to be achievable by 2030, 2040 and 2050, the item is highlighted with a **red mark**, denoting that it is an area that will require particular action in its implementation. Where there was insufficient information, or insufficient agreement among responses, the item is highlighted with an **orange mark**, denoting that it is an area that requires additional information and consultation.

- **[data gap] Social networks**: The promotion of cohesive and engaged communities is one of the drivers of urban resilience with the most robust empirical evidence (Therrien et al., 2018). As a result, many grassroots groups and local government authorities are actively promoting urban resilience by building tightly knit community networks, in particular in informal neighbourhoods. Asia is progressing from a top-down vision to a bottom-up approach to resilience planning. Governments in the region are starting to engage citizens and local communities in policy-making processes, as local stakeholders are directly affected by floods, landslides and heatwaves and have deep understanding of their specific needs in terms of risk prevention. When community residents and neighbours form close relationships, they can better understand and respond to the changing needs of others, in particular the most vulnerable, the elderly and children.
- **[data gap] Adaptation tools to extreme weather**: Each year, tens of thousands of people die from extreme heat and extreme cold. Heatwaves are estimated to cause 12 000 deaths annually across the world. The World Health Organization forecasts that

by 2030 there will be almost 92 000 deaths per year from heatwaves, with that figure expected to rise in 2050 to 255 000 deaths annually unless national and local governments adapt to heat-related risks (WHO, 2014). Building envelope efficiency and thermal comfort systems can reduce the impact of extreme climate conditions. This includes achieving the targets for envelope thermal resistance, air sealing, heating, cooling and ventilation in other activities. Measures also include providing cool spaces for people to shelter from extreme heat. Furthermore, strategies for improved resilience to heavy rain, wind, land movements or any other hazards should be developed for relevant risk zones.

- [data gap] **Storm-water management**: In the wake of Hurricane Sandy and the increase in frequency and severity of climate impacts in urban areas, the paradigm of Design with Nature first conceptualised by Ian McHarg has generated new thinking and momentum. Impervious surfaces in urban areas such as asphalt and concrete constrain natural drainage, exacerbating peak flows and flood risks. In many coastal cities, wetlands are turned into hard surfaces and mangroves are cleared to make space for construction, removing important buffers against floods and storms. By safeguarding natural buffers to enhance ecosystems' protective functions and designing parks and green features (e.g. bioswales), urban planning and landscape design interventions can optimise rain-capture potential and enhance protection from extreme rains. In broader terms, "green infrastructure" (e.g. parks, greening of pedestrian corridors, permeable vegetated surfaces, street trees, community gardens and urban wetlands) is an important tool to enhance resilience through an ecosystem services approach (United Nations Task Team on Habitat III, 2015).

- [data gap] **Resilience of critical infrastructure**: Every city should have a resilient power strategy to ensure that critical public and private facilities (water systems, hospitals, roads) can keep operating, the communication systems running, and emergency services remain functional in the event of a power disruption. Resilient power technologies such as solar plus battery storage to protect critical facilities from power outages now enable this function (NREL, 2018). Embedded microgrids, which include renewable energy distributed generation combined with energy storage, load management and smart systems, can disconnect from the main grid through "adaptive islanding" in the event of major disruptions. These microgrid solutions are emerging as a key element of urban energy systems resilience (Ostefeld, Whitemeyer and Von Meyer, 2018).

Box 23 •Regional examples of technologies for resilience

Hong Kong

Hong Kong, is prone to tropical cyclones with an average rainfall of 2 400 millimetres. This has led to constant flooding of the city in the past few decades. Taking into consideration the threat of climate change, the Drainage Services Department is implementing measures including construction of storm-water interception tunnels, storm-water storage tanks and upgrades of drainage pipework with the aim of building up flood resilience. The city itself is being designed like a sponge with high evaporation, high infiltration and low surface run-off with the implementation of strategies such as green roofs, rain gardens, retention lakes, porous pavements, water harvesting, bioswales, wetlands and river revitalisations. Future plans includes the development of flood retention lakes and reservoirs (Leung, 2017).

Low-cost earthquake-resistant construction methods in Pakistan

Modern building materials and methods such as concrete and masonry construction are deadly when improperly constructed and require the use of high-cost, energy-intensive materials and skilled labour, which are largely unaffordable for the poor. The Pakistan Straw Bale and Appropriate Building (PAKSBAB) promotes

construction of houses using compressed straw tied into bales for low-income families in northern Pakistan in response to earthquake hazards (PAKSBAB, n.d.).

Singapore's multifunctional urban spaces for flood management

As a low-lying island, Singapore faces existential challenges from rising sea levels. Approximately 30% of the city state lies less than 5 metres above mean sea level. PUB, Singapore's national water agency, launched its Active, Beautiful, Clean Waters (ABC Waters) programme in 2006 to convert waterways and waterbodies into urban assets by integrating drainage infrastructure within the built environment.

In Singapore, the idea of multifunctional urban spaces for flood management is advocated in the Housing Development Board Biophilic Town Framework, which serves to guide the enhancement of existing natural assets and the development of residential landscapes to enhance liveability. The framework's guidelines on flood and hazard mitigation suggests designing multifunctional green and open spaces (e.g. sports fields, outdoor basketball courts, paved plazas) to function as emergency flood detention basins during extreme storm events. The incorporation of building with nature and nature-based features in multifunctional spaces was also identified for further exploration in the 2018 ABC Waters design guidelines, which has transformed how Singapore manages surface water run-off.

Japan's first microgrid community

In Japan, after the March 2011 tsunami, the Higashimatsushima city suffered from flooding, which resulted in significant loss of lives and electricity outages of up to three months. The city exemplifies resilience thinking in its approach to reconstruction. Higashi Matsushima City Smart Disaster Prevention Eco Town was built and officially opened in June 2016. It was funded by the Ministry of Environment as part of the National Resilience Programme. This is Japan's first disaster-proof microgrid community powered by solar PV and biodiesel generators. The community also includes four hospitals, a few public buildings and a park. Smart meters on all local facilities will allow real-time monitoring of consumption. Energy loads will be served by the integration of distributed clean energy together with a large-scale energy storage system (Power Technology, 2018). When the centralised power grid becomes unavailable, the community will be able to function autonomously.

What is unique about this project is the town's electrical grid infrastructure is developed and owned by the city, which has accordingly invested in a smart grid infrastructure, building grid lines, poles and distribution substations, and installing smart meters. At the same time, the city has worked closely with housing developer Sekisui House to embed resilience in new buildings. The city of Higashimatsushima aims to be a zero net energy city by 2022. The key pillars of the Higashimatsushima form a framework that can be replicated across Japan, combining electricity production from local energy sources with smart EMS, with the twin goals of decarbonising the grid while maximising disaster resilience (Power Technology, 2018)

Finance for resilience

The sizeable gap between investment in resilience and conventional disaster response spending needs to be addressed. According to some estimates, for every USD 100 spent in overseas development aid, only USD 0.40 is invested in anticipating and planning for the impact of disasters. At the same time, the cost of disasters in developing and emerging countries amounted to USD 862 billion between 2013 and 2015 – and UN Habitat states that this may be significantly under-estimated (United Nations Task Team on Habitat III, 2015). This is equivalent in value to one-third of all international development aid during the same period. Therefore, finance can enable increased action towards having resilient buildings. Specific finance sub-targets and timelines are outlined below.

Financial tools particularly relevant to funding resilience in buildings may include:

- **Insurance**: More intense or frequent extreme weather events will affect property insurance. Insurance providers can encourage action to reduce risk exposure by giving resilience ratings to buildings, which could lead to lower premiums (CISL, 2014). Insurance products can also be tailored specifically to clean technologies and emissions reduction activities (e.g. parametric climate insurance).
- **Urban development funds**: Dedicated funding for urban development projects, which can prioritise resilient urban development projects.

- **Infrastructure funds**: Dedicated funding for infrastructure projects, which can prioritise sustainable infrastructure projects.
- **Dedicated credit lines**: Funding delivered through banks for a specific purpose, which can prioritise sustainable buildings, construction or development projects. Dedicated credit lines to national or local governments can also be used to establish a revolving loan fund, which collects repaid loans for energy efficiency projects and reinvests them in additional energy efficiency projects.
- **Risk-sharing loan/loan guarantee/concessional loan**: Large organisation (such as a government, international bank or aid organisation) covering the risk of payment default, offering below-market interest rates, or offering longer grace periods for repayment to enable banks to fund a project with lower costs and therefore better loan terms.
- **Green bonds**: Bonds that can be used to bundle funding for projects with climate or environmental benefits.
- **Grants and rebates**: Direct funding to overcome upfront cost barriers, provided by a government, organisation or programme either through a competitive process (grants) or during or after the purchase of a sustainable product or service (rebates).
- **Community finance and crowdfunding**: Collective funding from a large number of people connected either locally or through a call for funding.

Capacity building for resilience

Information combined with capacity-building activities can increase overall awareness, improve the decision-making process and encourage more sustainable choices. Training for professionals working directly with the built environment can enable increased resources and capacity to deliver resilient buildings.

The types of capacity-building activities relevant to materials are mapped in Table 21, where the darker the colour, the higher the impact that capacity building type has for this activity.

Table 21 • Capacity building for resilience in Asia

Training within government	Training of professionals	Training of product/material manufacturers	Training of financiers and developers	Training of general public

Note: The darker the colour, the higher the impact that capacity building type has for this activity.

Details regarding the most critical capacity-building activities are explained below:

- **Training within government**: Provide training to central and local governments about assessing climate risks, developing vulnerability maps and collaborating across multi-stakeholders regarding the development of integrated policies aiming at enhancing resilience in the built environment. Provide training regarding how to communicate the risks and the benefits associated with improved resilience. This will require data collection and analysis to enable the creation of databases, resource platforms and information campaigns.
- **Training of professionals**: Provide training programmes for service and product providers of buildings and construction (architects, engineers, contractors, installers etc.) regarding how to design buildings with increased resilience to climate risks. Provide training on how

to comply with policies such as resilience requirements in building codes or urban plans. Develop educational programmes including primary, secondary, vocational, university and adult education, to enable increased knowledge of resilience.

- **Training of general public**: Provide training for general public how to monitor climate risks and respective adaptation strategies. In particular provide access to information on measures and available resources (programmes, finance) to improve the resilience of living and working environments.

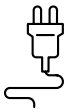
Further details regarding capacity-building activities are provided in the section Roadmap support: Enablers.

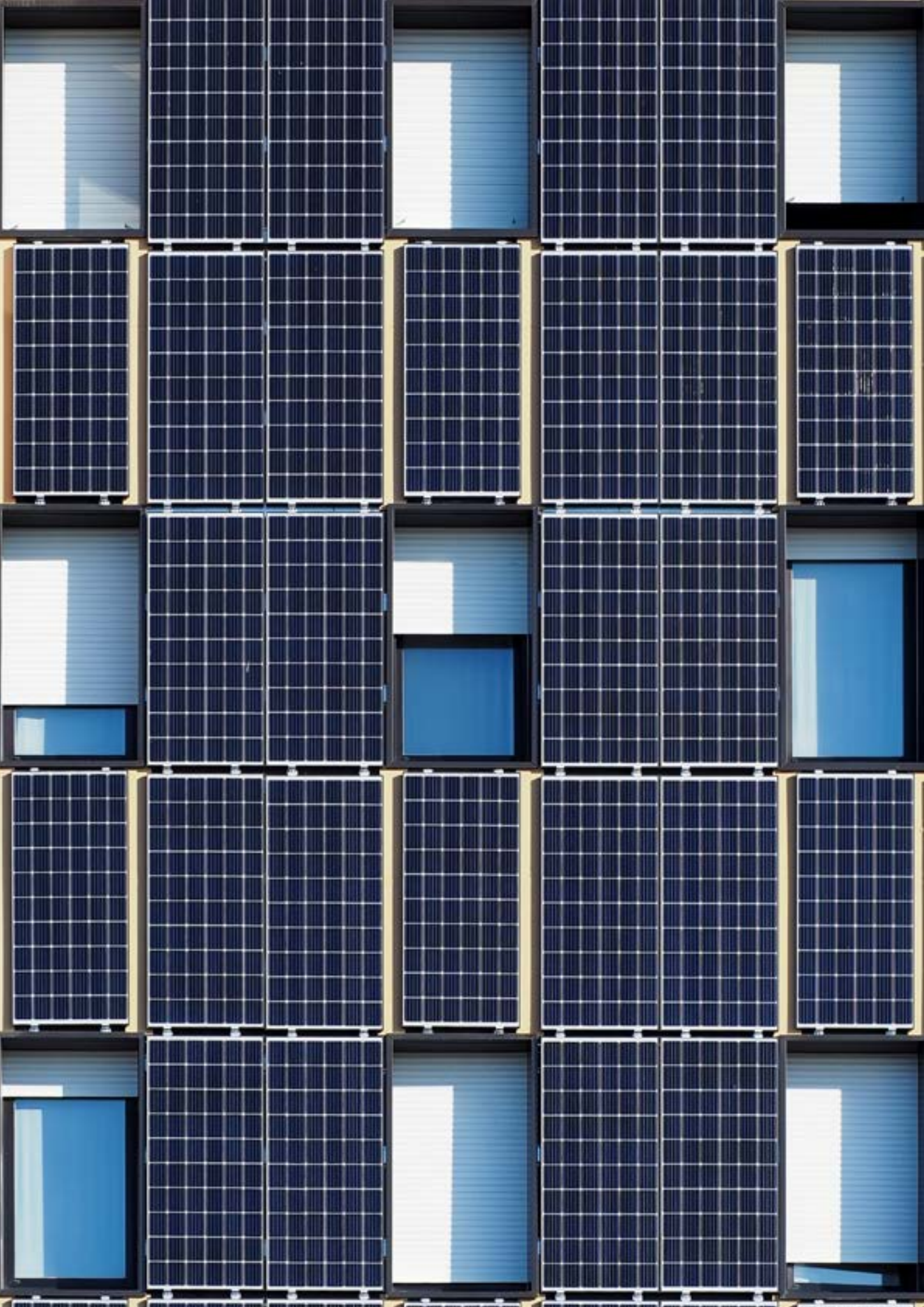
Multiple benefits of resilient buildings

Many benefits can be achieved through resilient buildings. Many of them are aligned with the SDGs, including Goal 7 (affordable and clean energy), Goal 11 (sustainable cities and communities), Goal 12 (responsible consumption and production) and Goal 13 (climate action).

Some of these benefits are described in Table 22, although many of them require further analysis to quantify them:

Table 22 • Multiple benefits of resilient buildings

Environment
 • **Resource efficiency –** resilient buildings have a longer useful life.
Energy
 • **Energy savings –** buildings designed to withstand extreme heat and cold are more energy efficient; buildings resilient to natural disasters have a longer useful life.
Economy
 • **Productivity –** resilience reduces operational disruption to cities and services. • **Asset value –** resilient buildings have lower risk of damage due to extreme weather events or natural disasters, improving property values and reducing insurance costs.
Society
 • **Poverty alleviation –** resilient buildings can better withstand extreme weather events or natural disasters, reducing loss of homes and infrastructure. • **Health and well-being –** resilient, durable buildings can withstand extreme weather events or natural disasters, delivering improved physical and mental health and well-being. • **Safety and security –** resilient buildings can withstand extreme weather leading to increased safety and security of their occupants.



Activity 8: Clean energy

Buildings in Asia account for 27% of final energy consumption, and good management of their energy supply and demand will be key to enabling a transition to clean energy. Shifting to clean energy sources allows for reduced fossil fuel dependency, greater energy autonomy, reduced environmental impacts, reduced GHG emissions and climate change mitigation, as well as provide employment opportunities. Energy service companies can help overcome high upfront costs for renewable and energy efficiency companies, making their diffusion broader, while demand-response and energy storage can play an important role in enabling a greater penetration of variable renewables in the energy mix.

Box 24 • Clean energy in Asia: Trends and challenges

With its rich natural sources of sunlight, wind, wave and tidal, Asia is rich in potential to produce renewable or clean energy. China is ahead in utilising renewable energy (World Energy Council, 2019). Municipalities in China are adopting clean energy plans on the local level. The municipal authorities of Zhangjiakou City have adopted a 30-year roadmap to phase out power generation by coal and increase solar and wind power instead.

It's also noteworthy that even the smaller countries in Asia such as Indonesia and Viet Nam are manufacturing solar, wind and also battery technology to generate clean energy. There are also some small hydropower projects in Southeast Asia in Indonesia, Malaysia, the Philippines, Thailand and Viet Nam. Challenges remain around the lack of funding available, the lack of regulation, and low energy prices making investments expensive.

Market sustainability of clean energy is still a challenge, with only few Asian countries such as the Philippines and Singapore reaching grid parity for solar (The Business Times, 2019). Increasing the market size for clean energy can help stimulate the supply chain and lower the costs. Incentives or regulations to install PV on distribution scale, for example, can be effective in significantly increasing the market size.

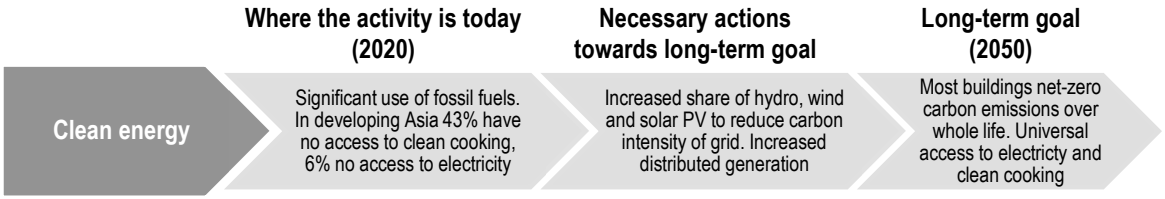
One of the key issues to tackle is the space availability for the renewable energy system implementation in the urban cities. Singapore has started the solar-ready roof programme where all new residential blocks with more than 400 m2 are designed to be solar-ready. This means the services on the roof are arranged in a way to optimise the rooftop space with electrical and structural supports for the panels catered for.

Electrification remains a challenge in Asia, especially for rural areas and islands not connected with the grid. Energy access and energy security remain as important goals for Asian policy makers and are drivers of their decision-making. Conventional power sources such as coal remain as their preferred technologies. For example, Southeast Asia is the main region where the share of coal in the power mix is expected to increase further due to new investments in new coal-fired power plants (IEA, 2019g).

Developing Asia is home to around 65% of the global population without access to clean cooking facilities, with 1.7 billion people relying on biomass, kerosene or coal as their primary cooking fuel. Clean cooking should reach 100% by 2030 based on SDG 7.1. Recent progress shows over 600 million people gaining access since 2010, with India reaching 49% and China 71% access rates in 2018 (IEA, n.d.).

Key actions for clean energy

Figure 35 • Key actions for clean energy in Asia



Key actions to enable the clean energy transition for buildings include:

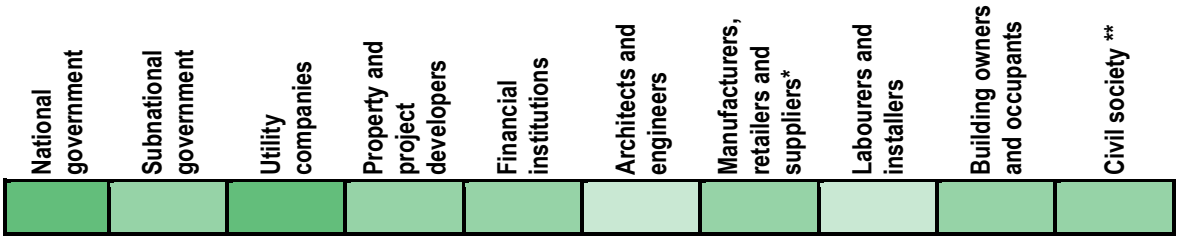
- **Eliminate on-site fossil fuel burning equipment**. Replace on-site fossil fuel burning systems with equipment that uses clean energy, e.g. for heat pump technology. Connect buildings to clean district energy systems when they are planned and can upgrade to clean energy.
- **Accelerate access to universal access to clean cooking and to electricity.** Continue progress on electrification, still lacking in remote areas and overburdened cities. Closing this gap will require private-sector financing, robust policy-planning frameworks, distributed renewables, and extension and strengthening of electricity grids. In order to reach access to clean cooking by 2030 for the almost 1.7 billion still lacking, solutions will include liquefied petroleum gas (LPG) in cities, and improved biomass or solar thermal in rural areas, with electric devices emerging as possible cost-effective solutions
- **Integration of on-site renewable energy**. Accelerate the adoption of decentralised renewable energy systems, such as PV, building integrated PV, solar thermal, micro-wind and energy storage projects in the planning and design of buildings and neighbourhoods. Lowering regulatory and financial barriers is key to widespread adoption of these technologies by building developers and households.
- **Update regulatory framework and incorporate renewables in utility planning**. Different Asian countries have varying degrees of liberalisation and decentralisation of their electric power industries. For those with centrally planned structures, a more direct planning and resource allocation would be necessary for introducing renewable energy. For those with more liberalised markets, updates in the regulatory framework to incentivise utility-scale and distributed renewable energy developers would be necessary. Stable regulatory frameworks are key to provide investors with the long term visibility needed for renewable investments.
- **Provide adequate financial incentives and reflective pricing of energy**. Value-added tax exemptions, and near-zero or zero-interest loan rates help spur investments towards clean energy. Measures such as feed-in tariffs help spur utility-scale investments, while establishment of net metering or peer-to-peer energy trading help spur distributed renewable energy investments. Such investments should be used with a clear timeline of their applicability.
- **Green power procurement**. In cases where local distributed generation is not sufficient to meet the local energy demand, buildings and neighbourhoods can buy clean energy from the grid through power purchase agreements (PPAs). Depending on the country's power sector structure, some regulatory changes might be needed to enable the conditions to allow for such procurement to take place.
- **Zero-carbon policies**. Create and implement zero-carbon policies in order to unify the different aspects of the buildings and construction life cycle towards a common goal of net zero. This allows the different stakeholders to balance out the efforts towards material and energy efficiency, on-site clean energy production and carbon capture in an optimal way.

Stakeholders for clean energy

In Asia, the key stakeholders for clean energy include those that can influence the availability of clean energy technology and services and those that can deliver the results of clean energy supply to buildings. Additional stakeholders include those that can support the process through research, funding and training.

These stakeholders are mapped in Table 23, where the darker the colour, the higher the impact that stakeholder group has on the activity and the more essential they are to delivering the roadmap targets.

Table 23 • Stakeholder mapping for clean energy in Asia



* of appliances and materials.

** including academia, NGOs, research institutions, social networks and community associations.

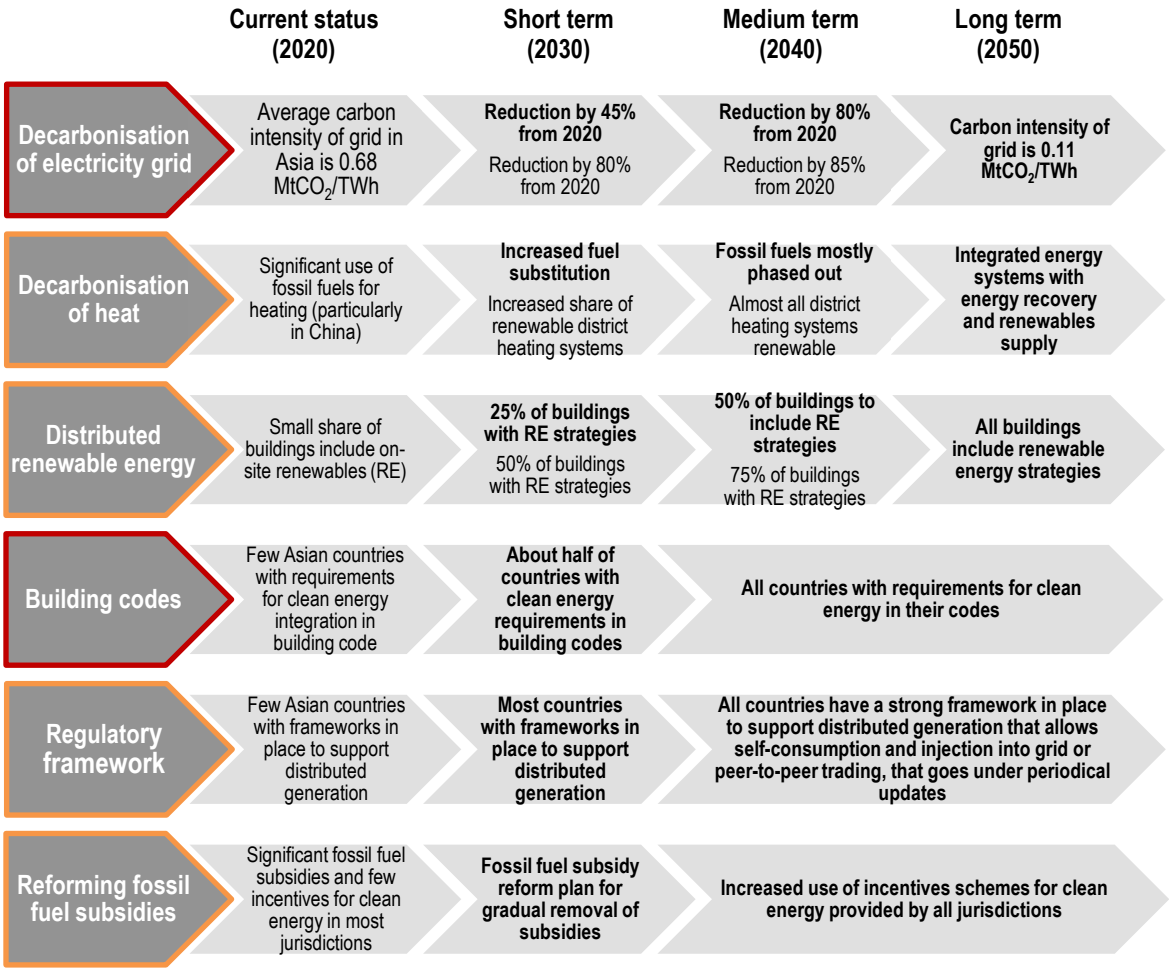
How to read: The darker the colour, the higher the impact that stakeholder group has on the activity and the more essential they are to delivering the roadmap targets.

Policy for clean energy

Clean energy policy supports zero-emission, efficient and resilient buildings by enabling the decarbonisation of the energy used in buildings and in the production of their construction materials.

Within the targets for clean energy, the policy timelines in Figure 36 offer more details:

Figure 36 • Policy timelines for clean energy in Asia



Notes: The **proposed regional target** is in **bold**. Below that is the proposed accelerated target. A red border indicates an ambition gap for that target (more details below); an orange border indicates a gap in data or consensus (more details below).

Details on the policy targets for clean energy are outlined below. For each item, in *italic* is a description of the consensus among the consulted local building experts regarding the evolution of the item between now and 2050. Where there was a significant gap between what was expected to be achievable by 2030, 2040 and 2050, the item is highlighted with a **red mark**, denoting that it is an area that will require particular action in its implementation. Where there was insufficient information, or insufficient agreement among responses, the item is highlighted with an **orange mark**, denoting that it is an area that requires additional information and consultation.

- **[ambition gap] Decarbonisation of electricity grid**: The power supply in Asia is still predominantly reliant on coal. Traditional sources of low-carbon electricity such as hydro and geothermal, geographically limited to the areas such as the Himalayas and the

Maritime Asian region, are widely exploited already and current installed capacity for variable renewable energy (VRE) is still low. Decarbonisation would involve massive investments in these VRE technologies, and early market or regulatory changes to ensure their integration. High solar potential in South and Southeast Asia and high wind potential in East Asia serve as indications for the possibilities in decarbonisation. Decarbonising the grid should take into consideration the impacts of decarbonising the end uses (see "Activity 5: Appliances and systems"), which might involve switching to electricity.

- [data gap] **Decarbonisation of heat**: While mostly applicable to China due to its high share of heating energy consumption, this measure addresses the decarbonisation of heat used in buildings. Decarbonisation will be possible thanks to increased penetration of renewable electricity systems, fuel substitutions away from fossil fuels, heat recovery and renewable district heating systems. Heating systems should aim to be fully integrated with the wider energy system, using heat and cold storage as flexibility mechanisms for the system.

- [data gap] **Distributed renewable energy**: At the building level, on-site renewable generation is one of the possible strategies to achieve net-zero energy and net-zero carbon standards. Buildings may fully or partially meet their energy needs with local heat and electricity generation systems (solar PV, solar thermal, biogas and geothermal, among others). Local production of renewable heat and electricity to displace fossil fuel consumption offers multiple benefits, including not only lower environmental impacts (e.g. GHG emissions, particulate emissions, etc.) but also energy diversification resulting in greater energy security and lower energy dependency for import countries, and greater possibilities of local energy governance at community level. The widespread adoption of distributed energy generation can be further encouraged through feasibility studies for the installation of on-site generation projects in new and existing buildings. *Stakeholder feedback: As large portions of the populations in Asia are yet to be electrified, bottom-up approaches of electrification via off-grid community-scale distributed renewable energy can increase the size of the market and achieve energy access goals at the same time.*

- [ambition gap] **Building codes**: The incorporation of measures such as readiness for demand-side response measures, obligations for renewable energy systems or provisions for their future installation (e.g. structural integrity requirements) can be stipulated in building codes. The codes should be developed jointly among national authorities, builders and other stakeholders so appropriate technologies are considered and mandatory requirements are applicable, enforceable, and well-designed. Building codes also should include requirements in structural integrity or other requirements which will enable the safe inclusion of on-site renewable energy systems. *Stakeholder feedback: Some respondents appear to believe that building codes could include requirements for renewable energy generation by 2040 to 2050, although there is little consensus.*

- [data gap] **Regulatory framework**: Regulatory frameworks define operating rules, connection permits, and the use of networks for distributed resources, goals, incentives, market conditions, prices for surpluses and other factors that allow an easy adoption of on-site generation. In this sense, a clear, simple, well-designed, updated and consistent regulation framework can facilitate widespread adoption. Frameworks covering technical regulations and administrative provisions for multi-dwelling PV or solar thermal installations can also help increase uptake in dense urban environments.

- [data gap] **Reforming fossil fuel subsidies**: The environmental and health costs of fossil fuel usage should be accounted for when comparing the costs of fossil fuels to those of renewable energy sources. This would mean phasing out of fossil fuel subsidies and setting appropriate taxation wherever applicable. Rolling back subsidies may be complemented

with more targeted social welfare measures, to mitigate the socio-economic impacts on the population, in particularly the most vulnerable. In developing Asia,[16] subsidies for kerosene, generally used for lighting, cost USD 10.2 billion per year (Evan, 2017). Subsidy reforms could enable replacements such as solar lighting distribution instead. Similarly, incentives can be used to promote renewable energy. These incentives can be non-financial, like expedited product approvals and permits, or financial. The former offers appropriate enabling conditions for the development of renewable energy technology, while the latter can substantially accelerate its deployment by encouraging private investment.

Box 25 • Regional examples of policy action for clean energy

Afghanistan's renewable energy plan to improve access to electricity

With only one-third of Afghanistan having access to electricity, the country is promoting renewables through the Energy Sector Improvement Programme. Universities are providing training programmes for local electricity providers and other businesses in support of this. Two pilot projects have been set up in northern Afghanistan using micro-hydropower and solar power.

India's requirements for rooftop PV installation

In India's Energy Conservation Building Code (ECBC) 2017, a renewable energy generating zone requires at least 25% of the roof area or an energy generation equivalent of 1% of total electrical load be provided for in all buildings covered by the code. Higher percentages are laid out for higher performance standards ECBC+ and SuperECBC, with minimum renewable electricity as much as 6% of total electrical load (BEE, 2017). The ECBC 2017 is a voluntary energy conservation code of India regulated by the BEE under the Ministry of Power. The code was first launched in 2007 and was again revised in 2017.

Korea increases its target for share of renewable energy

According to the Renewable Energy Application Standard issued by the Korean government in 2010, it was proposed to increase the application of renewable energy to 11% by 2035. To achieve this target, a budget of USD 548.69 million was used for mandatory on-grid tariff subsidies and construction of basic laws and regulations. The Korean government also established subsidies for renewable energy use in residential and other large-scale projects.

Malaysia investment targets for renewable energy

Malaysia needs investments totalling of 33 billion ringgits (MYR) in order to achieve its target of 20% electricity generation from renewable energy sources by 2025, and this includes clean energy for buildings. Out of the total electricity generated by Malaysia, only 2% of it comes from renewable energy sources.

Singapore plans for solar installations

To overcome Singapore's land constraints, the government has been aggregating and maximising solar installations on public-sector buildings under the SolarNova Programme, and aims to achieve 350 megawatts peak by 2020. Singapore has also set a new solar target of at least 2 gigawatts peak by 2030. The government will be working with companies, researchers and the public to scale up the adoption of solar power on rooftops as well as innovative spaces such as reservoirs, offshore and facades.

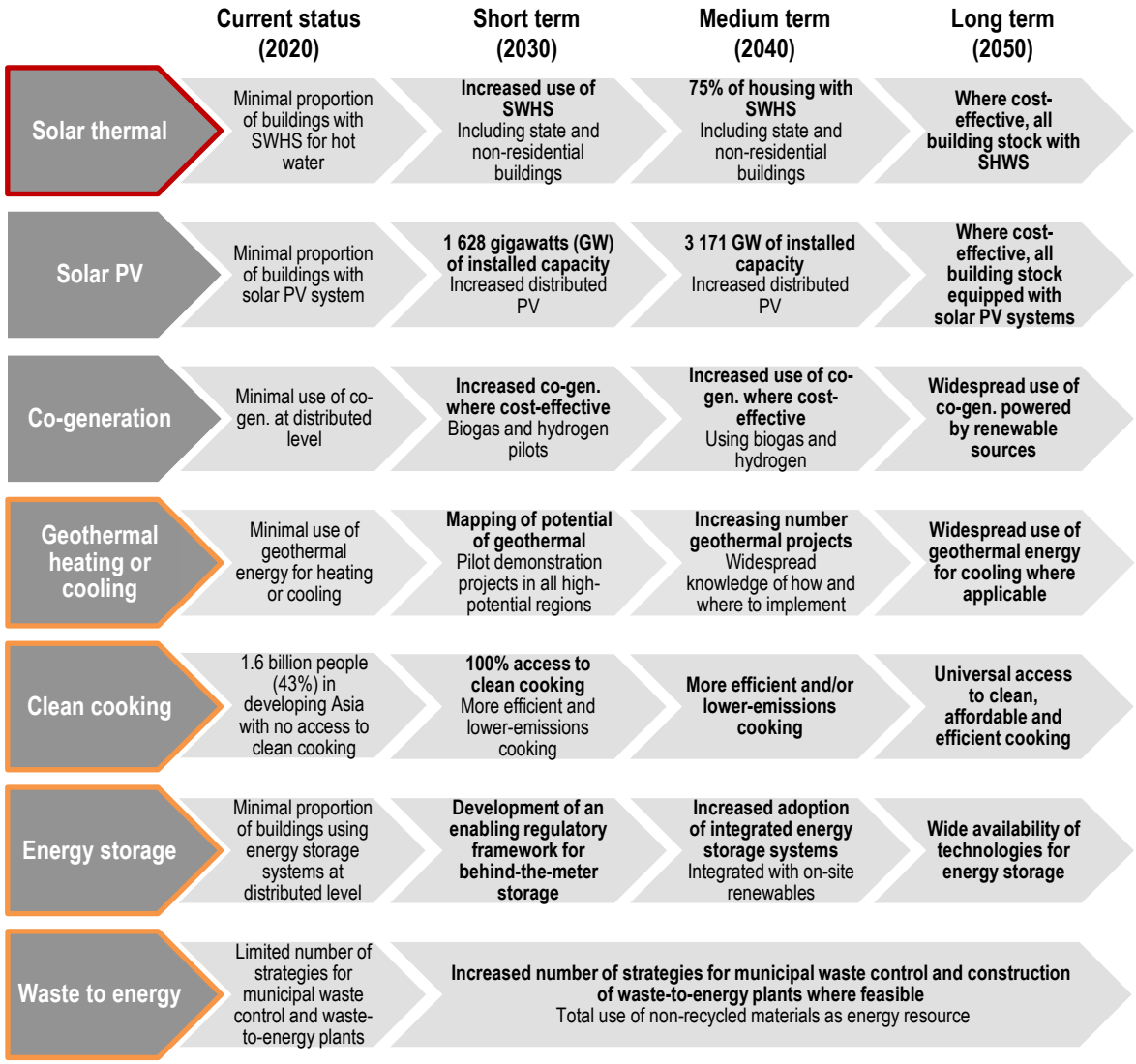
[16] Developing Asia based on the International Monetary Fund definition refers to Bangladesh, Cambodia, Lao PDR, Mongolia, Myanmar, Nepal and Sri Lanka.

Technology for clean energy

The life-cycle energy and emissions for buildings are influenced by the energy used in buildings.

Specific targets and timelines for clean energy are outlined in Figure 37:

Figure 37 • Technology timelines for clean energy in Asia



Notes: The **proposed regional target** is in **bold**. Below that is the proposed accelerated target. A red border indicates an ambition gap for that target (more details below); an orange border indicates a gap in data or consensus (more details below).

Details on the technology targets for clean energy are outlined below. For each item, in *italic* is a description of the consensus among the consulted local building experts regarding the evolution of the item between now and 2050. Where there was a significant gap between what was expected to be achievable by 2030, 2040 and 2050, the item is highlighted with a **red mark**, denoting that it is an area that will require particular action in its implementation. Where there was insufficient information, or insufficient agreement among responses, the item is highlighted with an **orange mark**, denoting that it is an area that requires additional information and consultation.

- **[ambition gap] Solar thermal**: On-site solar thermal collectors produce hot water in a renewable way and should be encouraged in areas of high solar radiation. Solar thermal systems have significant potential to displace electricity consumption from electric residential hot water production at a competitive price. *Stakeholder feedback: Solar thermal collection system technology has been developed in several Asian countries since as early as the 1960 to 1970s. Yet outside China, the use of solar thermal is currently low. There appears to be consensus in South and Southeast Asia that solar thermal collection system technology will not be widely used even by 2050.*

- **Solar PV**: On-site building-integrated or roof-mounted PV can enable the generation of electricity for self-consumption. According to the size of the installed system, buildings could partially or totally meet their electricity needs on an annual basis. Coupling with BESS can provide off-grid buildings with the required flexibility to meet their electricity demand at times of no generation (e.g. at night). Surpluses can also be delivered to the power grid by bidirectional metering. Low-voltage direct current (DC) home solar systems also offer significant potential for increasing access to electricity. The targets outlined above are based on the global capacity of solar PV in the IEA SDS (IEA, 2019a). *There is strong consensus that rooftop PV will be very widespread by 2050.*

- **Co-generation**: Co-generation can provide significant gains in terms of energy efficiency and reduction of CO_2 emissions in buildings by recovering waste heat from electricity production and using it for water and space heating. Co-generation can use a variety of fuels, from fossil fuels to biogas, biomass and even hydrogen. Co-generation systems can be expanded using tri-generation (combined cooling, heat and power) to also produce chilled water for space cooling. *Stakeholder feedback: There was consensus that combined heat and power would become more common but only among some building types.*

- **[data gap] Geothermal heating or cooling**: Geothermal systems exploit the earth or bodies of water as a heat sink, to provide heating or cooling. They can be used in combination with a heat pump, or where temperatures allow, in a direct circulation loop. Policy support in the form of risk guarantees or investment grants can help mitigate investment risks associated with high upfront costs and uncertain drilling operation outcomes. *Stakeholder feedback: Little information regarding the potential for geothermal energy in this region was obtained.*

- **[data gap] Clean cooking**: The use of traditional biomass for cooking is responsible for significant air pollution, deforestation and missed development opportunities. The benefits from switching from traditional biomass to clean energy for cooking are therefore multiple. In the IEA's SDS, a 95% reduction of traditional biomass makes it possible to reduce particle matter emissions by 97% by 2040 compared to 2018 (IEA, 2019a). There is no single solution and universal clean cooking can be achieved through a combination of switching to gas and electric cookers, efficient stoves and modern biomass, taking into account local circumstances and cultural acceptability. In 2018 access to clean cooking in developing Asia stood at 57% (IEA, 2019h). In the IEA SDS, this switch can be achieved through more than 200% increase in use of modern biomass and more than 90% reduction of traditional biomass for cooking, bringing down fine particle (PM 2.5) emissions by 96% by 2040 from 2018 (IEA, 2019a).

- **[data gap] Energy storage**: With increasing shares of variable and non-pilotable renewable energy in the energy supply, energy storage becomes an important element for balancing supply with demand. Thermal energy storage can be implemented at the

building or district scale, with higher cost-effectiveness at the latter. Coupled with solar thermal systems, heat storage tanks can ensure continued supply of hot water. Coupled with electric boilers or heat pumps, heat, chilled water or ice storage make it possible to avoid curtailment during periods of excess electricity production from variable renewable sources, and shift load to off-peak hours to lower the strain on the grid. BESS can store electricity for delayed uses, providing flexibility to off-grid buildings equipped with distributed variable renewable energy technologies, such as distributed PV. Time of Use (ToU) tariffs for electricity can incentivise the deployment of behind-the-meter BESS in connected buildings, as these BESS allow consumers to reduce grid-electricity consumption at peak hours and even potentially to sell electric surpluses to the grid, using bidirectional metering at the most profitable time. However, unless all BESS include bidirectional metering, on-grid storage offers a more economical and energy efficient solution than behind-the-meter storage from a system perspective, due to (i) economies of scale (ii) the smoothening effect from both demand and supply aggregation, which reduces the overall storage capacity needs, and the intensity of its use**.** For areas in Asia with more developed electricity industries, time-of-use tariffs and net billing could become key enablers for wider energy storage use (IRENA, 2019). *Stakeholder feedback: There was little consensus from respondents as to the role of energy storage systems.*

- [data gap] **Waste to energy**: Waste from buildings and construction that could not be avoided or recycled can be used as additional fuel input to municipal waste-to-energy plants. Although variability in the physical and chemical properties of waste makes it a less profitable combustible, waste-to-energy can provide a waste management alternative to landfill disposal. Landfill taxation and gate fees can help encourage the development of waste-to-energy.

Other clean energy technologies that do not have specific targets above include:

- **Small-scale hydro**: Historically, small-scale hydro was an important energy source for industrial buildings that were located near rivers. Currently, most small-scale hydro is directly fed into the power grid and not used on-site. It is common that these types of projects do not have storage capacity or water reservoirs, in contrast to large dammed hydroelectric plants.

Box 26 • Regional examples of technologies for clean energy

Solar Home Systems in Bangladesh

To fulfil the goals of providing energy access in Bangladesh, the Infrastructure Development Company Limited (IDCOL) began the Solar Home Systems (SHS) programme in 2003. With a 2003 electrification rate of only 40%, the SHS programme aimed to provide electricity for all citizens of Bangladesh by 2021 with an estimated generation capacity of 220 megawatts (MW). In 2019, it had already installed 4.13 million solar home systems, corresponding to about 12% of the total population. The combination of energy access and clean energy goals allowed it to avoid the consumption of around 3.6 million tonnes of kerosene used for lighting (IDCOL, 2019).

Rooftop solar PV and net-energy metering in Malaysia

Malaysia has targeted commercial and industrial buildings to go to rooftop solar and be the early adopters of the revised net energy metering (NEM) scheme to increase Malaysia's renewable energy mix from 2% to 20% by 2030. NEM offers lower tariffs, tax incentives, solar leasing programmes and reduced electricity bills to those who choose solar energy. Peninsular Malaysia has 4.12 million buildings with the potential to house solar panels on their rooftops. A massive 34 194 MW of electricity can be generated at any one time if these buildings are fitted with solar PV systems. Currently, Malaysia produces an average of only 24 000 MW at any one time. Ideally, if these roofs were equipped with solar, it could potentially produce more than the total electricity generated in Malaysia.

Malaysia improved the net metering system from 1 January 2019 by adopting the true NEM concept, allowing excess solar PV-generated energy to be exported back to the grid on a "one-on-one" offset basis. This means that every 1 kWh exported to the grid will be offset against 1 kWh consumed from the grid, instead of at the displaced cost previously.

Cost-effective PVs in China

After developing its solar PV industry through feed-in tariff subsidies, China has seen significant technological advances and cost reductions such that it was able to remove subsidies for new developments in its recent consultation paper (Government of China, 2019). These developments would allow China to achieve grid parity from 2021 or later.

In the larger picture, renewable energy is increasingly being integrated into electricity grids around the world, both from large wind and solar generation projects, and through distributed generation from PV systems installed on or integrated in buildings. However, the rapid uptake of renewables can lead to instability in power grids due to intermittent supply, and inefficient use due to a mismatch between periods of peak supply and peak demand. One potential solution is to design buildings to operate on DC electricity rather than alternating current. The new campus of the Shenzhen Institute for Building Research is demonstrating these opportunities. As with all good environmental design, the building optimises passive climatic design first, with mixed-mode ventilation, and efficient facade panels that integrate shading, high-performance glazing and thin-film PV panels. It also incorporates a DC system covering 5 000 m^2 of office and 50 residential units. This system incorporates both supply side from grid, on-site renewables and battery storage and demand side through DC operating appliances, lighting, smart controls and IoT integration.

Finance for clean energy

Finance can enable increased action towards clean energy for buildings. Financial tools particularly relevant to financing clean energy for buildings may include:

- **Green power procurement:** Depending on the regulatory framework, large electricity consumers can go to the competitive market to procure electricity directly from renewable energy projects or green-electricity retailers. In this way, buildings can support renewable utility- or distributed-scale projects through the creation of demand. Green power procurement is a common practice in some cities around the world, where municipalities decide to meet the electricity demand of public buildings through PPAs linked to renewable projects
- **Urban development funds:** Dedicated funding for urban development projects, which can be directed towards renewable energy projects.
- **Infrastructure funds:** Dedicated funding for infrastructure projects, which can be directed towards sustainable renewable infrastructure projects.
- **Dedicated credit lines:** Funding delivered through banks for a specific purpose, which can prioritise sustainable buildings, construction or development projects. Dedicated credit lines to national or local governments can also be used to establish a revolving loan fund, which collects repaid loans from renewable energy projects and re-invests them in additional energy efficiency or renewable energy projects.
- **Risk-sharing loan/loan guarantee:** Large organisations, such as a government, international bank or aid organisation, covering the risk of payment default to allow banks to fund a project with lower costs and better loan terms.
- **Green bonds:** Bonds that can be used to bundle funding associated with sustainable projects, including renewable energy projects.
- **Preferential tax:** Direct funding from the government to reduce or eliminate the tax for sustainable products and services, including renewable energy projects.

- **Grants and rebates:** Direct funding to overcome up-front cost barriers, provided by a government, organisation or programme either through a competitive process (grants) or during or after the purchase of a sustainable product or service (rebates).
- **Energy performance/energy service contracts:** Contracts for services or delivered savings that typically are delivered by an ESCO and can include a range of energy efficiency or renewable energy services and products.
- **Procurement purchase and lease:** The purchase or lease of sustainable products and services. Leasing enables the ability to use energy efficient products or renewable energy technologies on a rental basis to overcome high upfront capital expenditure.
- **On-bill/tax repayment:** An approach where any recurring bill, such as utility bills, insurance bills or home improvement store bills, can collect small amounts of money over a long period of time to pay for energy efficiency purchases in smaller payments. An offshoot of on-bill finance, tax repayment is where the tax authority uses recurring tax payments as a means for collecting money over time. The most common of these is PACE finance, which is able to use low-interest-loan repayments on the property tax bill until the purchase is full paid.
- **Community finance and crowdfunding:** Collective funding from a large number of people connected either locally or through a call for funding.
- **Energy prices:** Cost-reflective pricing and subsidies are powerful influencers of how people consume energy. Pricing strategies should consider decarbonisation goals. Time of use and location based pricing are other mechanisms by which pricing can influence consumption for a more robust integration of renewable energy.

Capacity building for clean energy

Information combined with capacity-building activities can increase overall awareness, improve the decision-making process and encourage more sustainable choices. Training for professionals working directly with the built environment can enable increased resources and capacity to deliver clean energy.

The types of capacity-building activities relevant to urban planning are mapped in Table 24, where the darker the colour, the higher the impact that capacity building type has for this activity.

Table 24 • Capacity building for clean energy in Asia

Training within government	Training of professionals	Training of product/material manufacturers	Training of financiers and developers	Training of general public

Note: The darker the colour, the higher the impact that capacity building type has for this activity.

Details regarding the most relevant capacity-building activities are explained below:

- **Training within government**: Build capacity and awareness in all levels of government on the benefits of clean energy production to the energy system, as well as broader benefits to infrastructure, public health and well-being, and the environment. Provide training on the integration of clean energy in all relevant aspects of policy planning, design and implementation, including in integrated resource planning, investment decisions, and urban planning and buildings sector policies, among others. Strengthen capacity in

co-ordination between relevant government and non-government organisations to enable improved policy coherence.

- **Training of financiers and developers**: Provide training to financiers and developers in identifying, assessing and financing clean energy projects, both at utility scale and distributed generation. Also build capacity in creating and nurturing stakeholder networks between policy makers, developers and financiers to build more project pipelines.

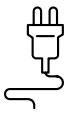
Further details regarding capacity-building activities are provided in the section Roadmap support: Enablers.

Multiple benefits of clean energy

Many benefits can be achieved through the clean energy transition. Many are aligned with the SDGs, including Goal 7 (affordable and clean energy), Goal 11 (sustainable cities and communities), Goal 12 (responsible consumption and production) and Goal 13 (climate action).

Some of these benefits are described in Table 25, although many of them require further analysis to quantify them:

Table 25 • Multiple benefits of clean energy

	Environment
	• **Emissions reductions –** clean energy reduces GHG emissions. • **Air quality –** many forms of clean energy produce no air pollution, improving air quality.
	Energy
	• **Energy security –** local clean energy solutions improve energy security by reducing reliance on fuel imports. • **Energy prices –** cost-competitive clean energy can reduce energy prices as generation profiles often have a strong overlap with peak demand profiles.
	Economy
	• **Economic performance –** clean energy delivers energy productivity improvements. • **Employment –** clean energy creates local jobs during the manufacturing, installation, and O&M of renewable energy systems.
	Society
	• **Poverty alleviation** - increasing access to reliable electricity and to clean forms of cooking can bring significant economic opportunity benefits to households. • **Health and well-being** - reducing indoor air pollution caused by the use of solid fuels, and by reducing time spent on energy collection or cooking activities increases both health and well-being.

Roadmap support: Enablers

Across all eight activity areas, cross-cutting actions are key to enabling their successful implementation: capacity building, financing and multi-stakeholder engagement. Capacity building enables people to understand and act on information that can support the achievement of zero-emission, efficient and resilient buildings. Financing is critical to turning policy and project ideas into reality. Multi-stakeholder engagement incorporates feedback from implementers and those affected, builds trust, and creates strong community buy-in to maintain momentum through leadership transitions.

Box 27 • Enabling activities in Asia: Trends and challenges

There are significant variations across sub regions in Asia on trends and challenges for capacity building, financing and multi-stakeholder engagement.

Challenges on data collection and reporting vary across the region, from lack of any clear mandate and concerns about data privacy in India to incomplete reporting due to fear of consequences for high energy consumption in Indonesia and Viet Nam to a government-required mandate for public buildings in China. Similarly, institutional co-ordination varies significantly across the region, from strong alignment between national and local GHG-reduction goals in Indonesia to disconnect among national ministries within India.

Across the region, more awareness is needed of how to integrate buildings and construction approaches with urban development and what connections exist with air pollution and public health. More demand is needed to incorporate green buildings in core curricula, which would help raise awareness. Training of local government officials on different building measures can help improve understanding of building codes and therefore improve compliance. For example, local officials who participated in walk-through building audits in Bandung and Jakarta, Indonesia, learned what different building measures do and how to check compliance.

Fostering a community of green building practitioners and advocates is also a powerful agent for change. Green building councils from the Asia-Pacific network have been key advocates particularly driving demand and capacity in the private sector.

Finance is affected by the weak data availability in parts of Asia, as this absence of data lowers the trust of financial institutions to lend to building efficiency projects. Green bonds are becoming more standardised and transparent in countries such as India, Indonesia, the Philippines and Viet Nam.

Capacity building

Capacity building is used to increase awareness, access and analysis of data and information. This includes data and tools to assess building emissions and energy consumption, information about co-ordination across institutions in the public sector or across sectors, and awareness of green buildings in education, training curricula and assessment of investment opportunities. Capacity-building activities can increase overall awareness, improve the decision-making process and encourage more sustainable choices. Training for professionals working directly with the built environment can enable increased resources and capacity to deliver zero-emission, efficient and resilient buildings.

Key actions for capacity building

Figure 38 • Key actions for capacity building in Asia

Key actions for capacity building in Asia include:

- **Data collection, analysis and reporting**. Enable robust data collection where it is scarce, including data on the value of sustainable buildings investments, and address concerns about privacy and consequences for reporting of high energy consumption as barriers to accurate data collection.
- **Institutional co-ordination**. Engage stakeholders especially across public sector entities to increase co-ordination, clarify meaningful roles and responsibilities, and establish agreed-upon targets and an approach to reach them (see Box 30 and section on multiple stakeholder engagement for more details).
- **Government training**. Increase training of local government officials on different building measures to improve awareness and code compliance.

Specific capacity building targets include:

Figure 39 • Timelines for capacity building actions

	Where the activity is today (2020)	Necessary actions towards long-term goal	Long term goal (2050)
Training within government	Significant regional variation in public-sector capacity and awareness Lack of institutional co-ordination	Training to raise capacity and awareness, training on stakeholder engagement	Well-trained public-sector officials leading co-ordinated action towards decarbonisation
Training of professionals	Some availability of and participation in professional training programmes	Develop training for service and product providers, building owners, and financial institutions, based on best practice in the region	Well-trained private-sector professionals implementing actions towards decarbonised buildings and construction
Educational training	Low integration of green building in school and university curricula	Develop curricula for all levels of education, learning from successful programmes within the region	Low-carbon buildings integrated in school, undergraduate and postgraduate education, with dedicated educational training on green buildings
Training of manufacturers	Little knowledge or incentive of how to improve performance of products and materials	Develop guidelines and training to support manufacturers and jointly develop strategies	Competitve manufacturers driving technology progress and innovation towards decarbonised building materials and efficient systems
Training of financiers and developers	Low understanding of benefits of zero-carbon buildings and materials, little standardisation and data for product comparison	Develop assessment methods, awareness of labels and rating systems to enable better communication of benefits	Zero-emission, efficient and resilient buildings leverage finance more easily than lower-performance projects and are seen as a good investment opportunity
Data collection and analysis	Significant regional variation in availability of baseline data on floor area, typologies, energy and emissions, or data tracking tools	Building control documents to increase data collection capacity, innovate on data management, and improve authorities' access to data	Standard availability of baseline data on floor area, typologies, energy and emissions, and tools to analyse and track data
Awareness of general public	Significant regional variation in awareness of the benefits of low-energy and low-carbon buildings and available tools	Develop methods for increasing information available to consumers, building on data collection and analysis	Standard availability of tools and information campaigns promoting informed decision-making among consumers

Capacity-building target details include:

- **Training within government**: Increased technical, financial and human resources in the public sector can improve the implementation and enforcement of policies. Building awareness is also crucial within government institutions on the benefits of green buildings and construction such as economic impacts, public health and well-being, and benefits to the energy sector and the environment. Shared goals and co-ordination within and among relevant government institutions and with NGOs can enable improved policy coherence. For example, national policy can create an enabling environment for local governments to accelerate action towards green buildings, and local policy is required for strong implementation.
- **Training of professionals**: Training programmes for service and product providers for buildings and construction (architects, developers, contractors, vendors, installers etc.) and building owners increase awareness of green buildings and construction policies, programmes or incentives for sustainable buildings and construction. This increases professionals' ability and willingness to implement these programmes.
- **Educational training**: Educational programmes including primary, secondary, vocational, university and adult education enable increased knowledge of green buildings. Certification or accreditation for professionals in the buildings sector can motivate more people to undertake educational training programmes, and increase awareness of who is trained to support green buildings and construction.
- **Training of product and material manufacturers**: This includes training for industry on how to comply with product and building standards as well as capacity building to enable the development and deployment of low-carbon solutions, such as increasing efficiency in manufacturing and construction processes and design, employing circular design principles, and strategies to increase recycling and reuse.
- **Training of financiers and developers**: Training and access to tools for financiers and developers to better identify, assess and finance investment opportunities in the zero-carbon, efficient and resilient buildings sector. Particularly important is a better understanding and assessment of the benefits of zero-carbon, efficient and resilient buildings within the broader context of climate risk exposure of buildings as assets. Moreover, capacity building is necessary to create stakeholder networks among policy makers, developers and financiers to set up project pipelines.
- **Training of the general public**: Information tools to increase awareness, improve decision-making and promote more sustainable choices by the general public. Methods of increasing information to consumers include benchmarking programmes, certification programmes, building passports, mandatory disclosure, labels, educational resources, and information on utility and government programmes.
- **Data collection and analysis**: Baseline data on building stock and typologies, energy consumption, and emissions is a critical first step to understanding the starting point and therefore how to improve to zero-emission buildings and calculate the multiple benefits there are to gain from the decarbonisation of buildings.

These elements of capacity building have differing relevance across the eight activity areas. A general indication of the relevance of each is mapped in Table 26, where the darker the colour of the box, the higher the impact that capacity building type has for that activity.

Table 26 • Types of capacity building across activities

	Training within government	Training of professionals	Training of product and materials manufacturers	Training financiers and developers	Training of the general public (incl. owners and occupants)
Urban planning					
New buildings					
Existing buildings					
Building operations					
Appliances and systems					
Materials					
Resilience					
Clean energy					

Note: The darker the colour, the higher the impact that capacity building type has for that activity.

Box 28 • Regional examples of action on capacity building

India

India does not have privacy laws like those in places such as the European Union, leading to issues in data collection. Vidyut Rakshaka, a programme working to change consumer behaviour based on lessons from their energy consumption, for example, encountered this issue during implementation and had to put in place non-disclosure agreements in order to undertake data collection.

Indonesia and Viet Nam

In Indonesia and Viet Nam, despite mandatory reporting, building owners are fearful of facing adverse consequences from reporting high energy consumption. As a result, they often either don't or partially report energy consumption data. Since there are no government checks on data validity, data are usually unverified, which hinders accurate benchmarking and, consequently, appropriate policy development.

ASEAN Centre for Energy

The ASEAN Centre for Energy is an example of a regional platform for collaboration among its member countries, providing a hub for data collection and statistics, regional awards, a business forum, and a training and certification platform providing standardised training for energy managers.

National Energy End-Use Monitoring (NEEM)

India's BEE and CLASP launched in 2019 a dashboard to monitor appliance energy use in the residential sector. Based on a household survey and electricity use monitoring data, this tool will be key in collecting valuable information on energy demand profiles for policy makers, power distribution companies, academia and others involved in designing policies and furthering research.

Finance

The IFC estimates that global investments in green buildings in 2017 accounted for about 8% of the resources spent on building construction and renovation – USD 423 billion of a USD 5 trillion market (IFC, 2019). Looking ahead with a focus on emerging market cities, there is a cumulative climate investment opportunity of USD 29.4 trillion to 2030, of which 84% – USD 24.7 trillion – is in green buildings. Of this, USD 17.8 trillion is in East Asia Pacific and South Asia, indicating an enormous opportunity in this region (IFC, 2019).

Zero-emission, resilient and efficient buildings and construction often face barriers because they require upfront investments from building owners for benefits that develop over several years. Those investments usually require incentives and financing to encourage building and construction stakeholders to make decisions in support of green buildings. And financiers have many requirements including stability, scale and standardisation that can slow their acceptance of building and construction projects that may not display these characteristics.

Key actions for finance

Figure 40 • Key actions for finance in Asia

Key actions for finance in Asia include:

- **Implementing financial tools:** Implementing a suite of financial tools – for example, revolving loan funds, grants and rebates, and infrastructure funds – can support investment in zero-emission, resilient and efficient buildings.
- **Rating tools and labelling:** Rating tools and labelling are important complementary policies for finance and incentive programs, as they provide independent verification for performance-based incentives (that provide incentives linked to exceeding a minimum performance benchmark).
- **Data collection and reporting**: Build and deploy data collection and reporting systems, as weak or unreliable data availability lowers trust of financial institutions to lend to sustainable buildings and construction projects.
- **Sharing regional best practice:** Share case studies across the region about successes and lessons learned to accelerate the growth of knowledge among buildings practitioners.

Financial tools relevant to financing zero-emission, resilient and efficient buildings include:

- **Urban development funds**: Dedicated funding for urban development projects, which can prioritise sustainable urban development projects.
- **Infrastructure funds**: Dedicated funding for infrastructure projects, which can prioritise sustainable infrastructure projects.
- **Dedicated credit lines**: Funding delivered through banks for a specific purpose, which can prioritise sustainable buildings, construction or development projects. Dedicated credit lines to national or local governments can also be used to establish a **revolving loan fund**, which collects repaid loans for energy efficiency projects and reinvests them in additional energy efficiency projects.
- **Risk-sharing loan/loan guarantee/concessional loan**: Large organisation (such as a government, international bank or aid organisation) covering the risk of payment default, offering below-market interest rates, or offering longer grace periods for repayment to enable banks to fund a project with lower costs and therefore better loan terms.
- **Green bonds**: Bonds that can be used to bundle funding for projects with climate or environmental benefits.
- **Preferential tax**: Direct funding from the government to reduce or eliminate taxes for sustainable products and services.
- **Grants and rebates**: Direct funding to overcome upfront cost barriers, provided by a government, organisation or programme either through a competitive process (grants) or during or after the purchase of a sustainable product or service (rebates).

- **Energy performance/energy service contracts**: Contracts for services or delivered savings that typically are delivered by an ESCO and can include a range of energy efficiency services and products.
- **Green mortgages**: Prospective homeowners can solicit additional finance as part of their mortgage to install efficient features and technologies in their future homes.
- **Procurement purchase and lease**: The purchase or lease of sustainable products and services. Leasing enables the use of energy-efficient products on a rental basis to reduce a capital expenditure.
- **On-bill/tax repayment**: An approach where any recurring bill, such as utility bills, insurance bills or home improvement store bills, can collect small amounts of money over a long period of time to pay for energy efficiency purchases in smaller payments. An offshoot of on-bill finance, tax repayment is where the tax authority uses recurring tax payments as a means for collecting money over time. The most common of these is PACE which is able to use low-interest-loan repayments on the property tax bill until the purchase is paid in full.
- **Community finance and crowdfunding**: Collective funding from a large number of people connected either locally or through a call for funding.

Box 29 • Regional examples of action on finance

ENCON fund for energy efficiency in Thailand

In 1992, Thailand enacted the Energy Conservation Promotion (ENCON) Act to encourage energy efficiency. The ENCON Act includes a compulsory programme, directed by the Ministry of Energy's Department of Alternative Energy Development and Energy Efficiency, for certain "designated factories and buildings" to manage energy use, conduct energy audits, set energy efficiency targets and develop a plan to reach these targets.

The ENCON Fund was financed by a levy of USD 0.001 per litre on petroleum products. The fund provides capital at no cost to Thai banks, which then provide low-interest loans with maximum loan terms of seven years to energy efficiency projects, including ESCOs. This has contributed to the rise of a thriving ESCO market for building efficiency in Thailand.

Singapore

Under the BREEF scheme, which provides loans for energy efficiency retrofit of existing buildings, the BCA of Singapore shares 40% of the risk of any loan default with the participating financial institutions.

China

Catastrophe insurance has been used by a few cities in China as a resilience measure. Several cities have this insurance purchased at the individual or household level, and in Guangdong province the government itself has catastrophe insurance.

ESCOs in India

India has a growing ESCO market, although ESCOs still encounter issues accessing finance for their energy efficiency projects due to the perceived financial risk of such projects. In order to develop and expand the ESCO market, the Small Industries Development Bank of India (SIDBI) has developed the partial risk sharing facility (PRSF) to build up a solid foundation of demonstration projects for energy efficiency lending.

The PRSF is a risk-sharing facility of USD 37 million that provides guarantees to financial institutions that lend to ESCOs, under the condition that the ESCO engages in a formal energy performance contract per project. The guarantee covers up to 75% of the total loan amount, with the minimum guarantee amount of approximately USD 15 000 and a maximum of USD 2 million and typical loan tenure up to five years.

The fund is administered by the SIDBI along with the World Bank and EESL India. The primary funders are the Global Environmental Facility and the Clean Technology Fund.

Green bonds in the Philippines

In January 2019 the Philippines' Rizal Commercial Banking Corp. (RCBC) issued its first green bond for USD 300 million. The bond proceeds will go towards a variety of projects, including expanding the bank's green

finance capacity, energy efficiency projects and green buildings, as well as social projects such as social housing and energy access. Definitions for qualifying and disqualifying projects are included in RCBC's recently developed Green Finance Framework.

The Green Finance Framework was developed to guide and deploy green financing instruments in the bank's portfolio. The bond was issued under the framework, which stipulates that bonds must align also with the international Green Bond Principles, the ASEAN Green Bond Standard, and the International Capital Market Association's Green Bond Principles. International alignment is essential for assessing the impact of proceeds, as not all nation/regional criteria align.

Multiple stakeholder engagement

Engagement with stakeholders across sectors offers the opportunity to gain feedback from a variety of perspectives, especially those that will support implementation of the roadmap (especially across the private sector) and those who will be affected by the policies. Multi-stakeholder engagement also creates strong community buy-in to maintain momentum through leadership transitions.

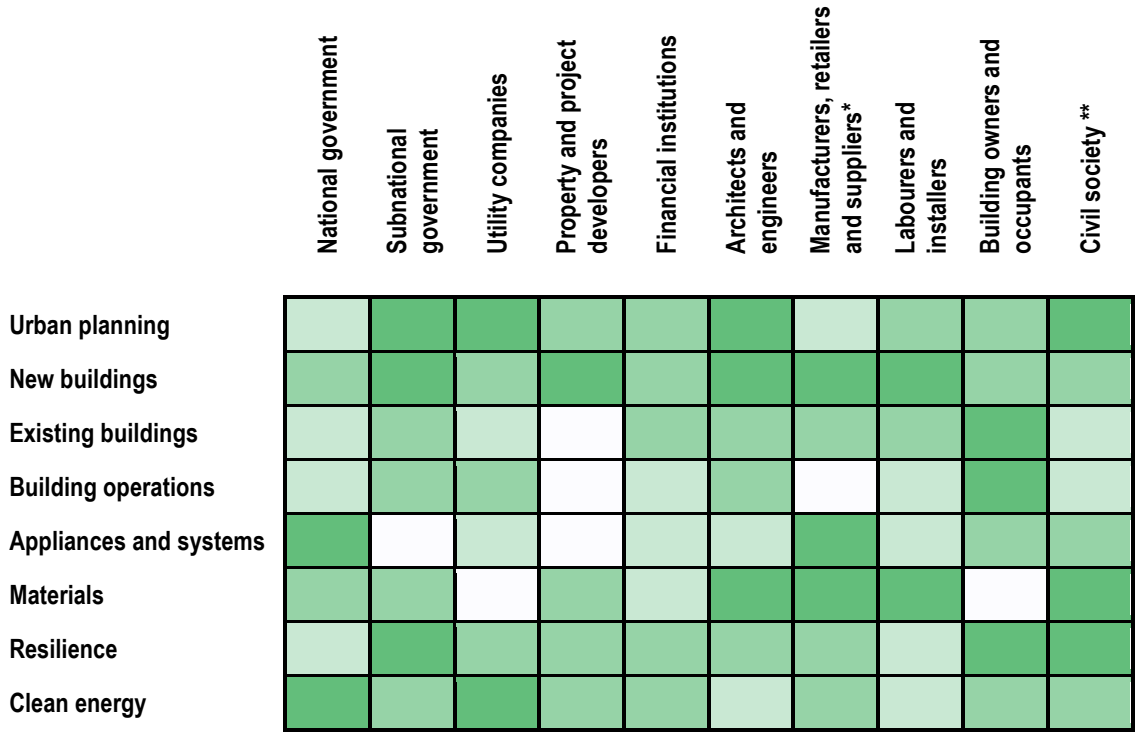
Stakeholders to be engaged include:

- **National government**: National governments design and implement policies that enable or disable the uptake of sustainable building and construction. National governments act as regulators and can play an important role in facilitating partnerships among other stakeholders.
- **Subnational government**: Subnational governments play a critical role in developing, implementing and enforcing policy. In addition to their regulatory role, cities and states can convene actors across sectors, and can take action as owners of public buildings.
- **Utility companies**: Utilities have significant building data and valuable relationships with owners and tenants that already include payment and financing. In some cases, utilities also have to comply with legislation to reduce their emissions. Utilities can therefore be either a significant barrier or enabler to action on sustainable buildings and construction.
- **Property and project developers**: Developers make decisions about how property will be used, including cost-benefit assessments for different building and construction approaches. These early decisions can have far-reaching impacts into what options are considered in a building or construction project.
- **Financial institutions**: Financiers provide mechanisms to make the necessary upfront investments for sustainable buildings and construction, with repayment often coming from the energy saving benefits that develop over several years.
- **Architects and engineers**: Professionals who lead on technical project design determine what is possible within the parameters set by developers. Professional and educational training provides these experts with the knowledge they need to incorporate sustainable building and construction design.
- **Manufacturers, retailers and suppliers**: Companies that make equipment and systems determine what products are available on the market, and whether building upgrade solutions are sold with a systems view or more piecemeal replacements over time.
- **Labourers and installers**: Construction professionals have to interpret project designs and bring them to life, and there are many opportunities for real-life installations to fall short of the sustainability envisioned in the designs on paper. Professional training is critical for labourers and installers to implement sustainable buildings and construction.

- **Building owners and occupants**: Owners and occupants are responsible for paying for any building upgrades and for energy bills, and get the benefit of improved energy services.
- **Civil society**: Civil society organisations, such as consumer and environmental advocates, or social service providers, can provide capacity and expertise to improve government decision-making. Civil society can represent the perspectives of communities that may otherwise be absent from buildings and construction dialogues.

The different stakeholders are mapped in Table 27 to show the relative importance each has to each of the eight areas, where the darker the colour, the higher the impact that stakeholder group has on the activity and the more essential it is to delivering the roadmap targets for that activity.

Table 27 • Stakeholder mapping across activities



* of appliances and materials.

** including academia, NGOs, research institutions, social networks, and community associations.

How to read: The darker the colour, the higher the impact that stakeholder group has on the activity and the more essential they are to delivering the roadmap targets.

Multi-stakeholder processes before and during policy design processes enable government decision-makers to assess the feasibility of different approaches, taking into consideration various needs and perspectives. Stakeholder engagement can also build relationships with key players, driving policy acceptance and improving participation and compliance.

Several approaches can facilitate stakeholder engagement. For instance, a **SWOT** (strengths, weaknesses, opportunities and threats) analysis can be facilitated collaboratively with stakeholders to better understand what will drive success of policy for sustainable buildings and construction and what threats to be aware of. **PIE** (progress, impact and effort) multi-matrix (such as the "Assessment tool for building efficiency policies" [Becqué et al., 2016) can seed stakeholder

discussion to prioritise policies for action. Stakeholders can collaboratively use a responsibility matrix such as **RACI** (responsible, accountable, consulted and informed) to clearly identify which roles are appropriate for each stakeholder throughout policy roadmap development and implementation.

Box 30 • Examples of mechanisms to facilitate institutional co-ordination

The "green building" community has a powerful part to play in convening the relevant stakeholders and actors including academia, the private sector and civil society; providing training; and generally raising awareness of the benefits of green buildings. Green building communities are present and growing in many of the countries across the region. Two examples of these types of communities are described below:

Green building councils

Green building councils (GBCs) facilitate institutional co-ordination of public, private and civil society by advocating for a more sustainable built environment, developing the capacity of the industry to build better buildings and raising awareness of the benefits of green buildings. The global GBC network is developing tools, programmes and resources to accelerate uptake of net-zero carbon buildings towards sector decarbonisation goals.

Across the Asia Pacific, established GBCs include: China, India, Indonesia, Japan Sustainable Building Consortium, Kazakhstan, Korea, Malaysia, Pakistan, the Philippines, Singapore, Chinese Taipei and Viet Nam.

National alliances

The GlobalABC helps promote national alliances that bring together key public, private and civil society stakeholders, to overcome the fragmented value chain and jointly work towards a zero-emission, efficient, and resilient buildings and construction sector.

National alliances offer recommendations for policy makers and actively work to enhance economic activity. Typical pursuits range from awareness raising, training sessions and project assistance to legislative lobbying.

National alliances have been successfully established in France, Germany, Mexico, Morocco and Tunisia, in many cases inspired by GlobalABC.

Conclusions and outlook

As shown throughout this document, buildings have a dominant role to play in the clean energy transition and towards reaching the SDGs and the New Urban Agenda. Yet the *2019 Global Status Report* highlights that this sector is not on track, as energy efficiency improvements are outpaced by rapidly expanding floor area and growth in demand for energy-consuming services. To counteract these trends, the global average building energy intensity per unit of floor area needs to be at least 30% lower than current levels by 2050 (IEA, 2019f), which means adopting both appropriate low-energy designs, and advanced building technologies and operation systems. Additionally, full decarbonisation of the sector will require a life-cycle approach to the built environment, looking into whole life cycle of buildings and materials and their embodied carbon, more sustainable and integrated urban planning and development, and adopting adaptation and resilience measures, among others.

This Asia Roadmap is a collective framework for the buildings and construction sector to align with the objective of the Paris Agreement, i.e. to limit the risk of climate change above 1.5°C through a decarbonised built environment. Across eight activities, or segments of the buildings and construction sector: urban planning, new buildings, existing buildings, building operations, appliances and systems, materials, resilience, and clean energy), this Asia Roadmap provides key actions, stakeholders mapping, policy and technology actions, finance actions, capacity building, and their multiple benefits.

This Asia Roadmap can serve as a tool for countries across the region to adopt ambitious and effective buildings and construction sector actions when undertaking the 2020-25 NDC revisions, even supporting the monitoring, reporting and verification process for NDCs. It also supports organisations in determining their buildings investments strategies by identifying goals and milestones, and supporting detailed national or local buildings and construction roadmaps. By creating a common vision for the whole sector, these documents aim to facilitate co-operation among the entire value chain in the buildings and construction sector, and also between countries and regions. The key actions for Asia across these activities set out the ingredients for policy and decision makers to include in their strategies and the elements needed to promote the development of a zero-emission, efficient and resilient building stock between now and 2050.

The path ahead is challenging but achievable. This document provides indicative targets and timelines for establishing both a proposed pathway of improvement in the planning, development, operation, servicing and resilience of the building stock in Asia, along with ambitious or “stretch” targets that allow countries and subnational entities to push further faster. It is the expectation that these documents, the themes, checklists, guides, recommendations, stakeholder mapping, examples and key actions can help guide policy-making and raise awareness to help build political argument for more ambitious buildings and construction policies and market signals.

Yet there is still much work to do. Although the Asia Roadmap is the product of extensive consultation and expert input, there are activities and action areas that need more data to ensure the proposed targets are set on a solid footing. There remains the need across the Asian buildings and construction sector to address information gaps and build the evidence base and support tools for zero-carbon development and planning, carbon and energy intensity of materials, and improving systems and processes to ensure buildings are resilient in the face of a changing climate. There is also the need to raise the level of ambition across all eight activities, in particular the adoption of high-performance technologies and use of low-carbon materials, for which all stakeholders along the building life cycle need to play their part.

Global effort in support of buildings and construction sector decarbonisation

Governments and stakeholders across the world are starting to take action towards buildings sector decarbonisation.

The GlobalABC was launched at COP21 as a voluntary partnership of national and local governments, inter-governmental organisations, businesses, associations, networks, and think tanks committed to a common vision: a zero-emission, efficient and resilient buildings and construction sector. The GlobalABC functions as an umbrella or meta-platform – a network of networks – that brings together initiatives and actors focusing on the buildings and construction sector.

Box 31 • The GlobalABC

By working with buildings and construction experts through a series of workshops, meetings, events and interactive dialogues, the GlobalABC with the IEA developed this roadmap that sets out actions towards decarbonising the sector through a comprehensive approach to buildings and construction. This document guides the GlobalABC in its efforts to raise ambition to meet the Paris climate goals and mobilise all actors along the buildings and construction value chain. Such efforts include:

- Keeping track of the sector through an annual buildings and construction global status report.
- Raising ambition levels by supporting countries in including ambitious, concrete buildings and construction climate actions into their NDCs (i.e. "A guide for incorporating buildings sector actions in NDCs").
- Shaping the global agenda: showcasing the potential of the buildings and construction sector for mitigation and adaption by giving the buildings and construction sector a voice in the global climate change debate.
- Forging regional pathways towards zero-emission, efficient, and resilient buildings and construction through stakeholder-driven regional roadmaps, based on our Global Roadmap.
- Promoting national alliances: supporting national governments to overcome the fra gmentation in the buildings and construction sector and ramp up the level of action. The GlobalABC so far has sparked three national alliances in Mexico, Morocco and Tunisia.
- Working with the GlobalABC-catalysed Programme for Energy Efficiency in Buildings (PEEB) and its first five partner countries Mexico, Morocco, Senegal, Tunisia and Viet Nam towards implementing actions towards decarbonising the buildings sector.

The GlobalABC, through these activities, aims to mobilise all actors along the value chain, identifying priorities and goals towards decarbonising the built environment, while fostering transparency, inclusion and co-operation. The Asia Roadmap is a key step in this process.

As part of the 2018 Clean Energy Ministerial, six GlobalABC member countries (Argentina, France, Germany, Mexico, Morocco and Switzerland) signed the Global Call for Low-Carbon, Energy-Efficient and Resilient Buildings to develop national strategies for buildings and construction in line with the Paris Agreement goals. Furthermore, multiple businesses, cities, and regions have signed up to the Net Zero Carbon Buildings Commitment, which challenges companies, cities, states and regions to reach net-zero operating emissions in their portfolios by 2030, and to advocate for all buildings to be net-zero in operation by 2050. And countries, the private sector, and financial institutions have signed up to the Zero Carbon Buildings for All Initiative as part of the UN Secretary-General's Climate Summit in 2019.

While this Asia Roadmap promotes a common language and vision, to accelerate progress, the approach of developing key actions and setting of targets across the buildings and construction sector illustrated by this roadmap can be cascaded to the regional, subregional, national and subnational levels to create locally owned and adopted roadmaps. To this end, the GlobalABC has cascaded the Global Roadmap to a series of Regional Roadmaps for Africa, Asia and Latin America, to serve as guidelines for regional and subregional action.

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Resources

The following are freely available resources that could be useful in developing a roadmap. Some of these resources have a broad view of the buildings sector while others include roadmaps for specific activities within the buildings sector, such as a roadmap for building codes or a roadmap for building renovation.

Key resources:

- Global Roadmap Towards Low-GhG and Resilient Buildings, Global Alliance for Buildings and Construction, 2016
- Recommendation for a Classification of Measures and Policies Related to Local Conditions, Ecofys Germany GmbH, 2017
- Science-Based Targets for Buildings, A Framework for Carbon Emissions Management Along the Building and Construction Value Chain, WBCSD, 2018
- Capturing the Multiple Benefits of Energy Efficiency, International Energy Agency, 2014

Additional Resources:

- Policy Pathway: Energy Performance Certification of Buildings, International Energy Agency, 2010
- Policy Pathway: Modernising Building Energy Codes, International Energy Agency, 2013
- Technology Roadmap: A Guide to Development and Implementation, International Energy Agency, 2014
- Technology Roadmap: Energy-Efficient Buildings Heating and Cooling Equipment, International Energy Agency, 2011
- Technology Roadmap: Energy Efficient Building Envelopes, International Energy Agency, 2013 Transition to Sustainable Buildings, International Energy Agency, 2013
- 25 Energy Efficiency Policy Recommendations, International Energy Agency, 2011
- Energy Efficiency Policy Recommendations: Arab-Southern and Eastern Mediterranean, International Energy Agency, 2014
- Energy Efficiency Policy Recommendations: Latin American and Caribbean, International Energy Agency, 2015
- Energy Efficiency Policy Recommendations: Southeast Asia Region, International Energy Agency, 2014

Additional roadmap projects that can be built on or used for inspiration:

- Roadmap for Implementation of Energy Efficiency in Public Buildings of Kyrgyz Republic, World Bank, 2019
- Super Low Energy Building Technology Roadmap, Singapore BCA, 2018 Nearly (Net) Zero Energy Building Roadmap, APEC, 2018
- A Carbon Positive Roadmap for the built environment, Green Building Council Australia, 2018
- Roadmap for Healthy Buildings – 1st step: Harmonisation of Health Criteria for Construction Products, German Environment Agency, 2018
- Roadmap to Healthy Low-Carbon Lifestyles, Cities and Buildings, Science Council of Japan, 2018

- A Roadmap for Retrofits in Canada: A Detailed Roadmap for Reducing Greenhouse Gas Emissions from Large Buildings, Canada Green Building Council, 2017
- Zero Energy Building Pathway to 2035, National Grid, 2016
- Policy Roadmap to 50% Energy Reduction in Chinese Buildings by 2050, LBNL, RMI and ERI, 2016
- Roadmap to Resilient, Net-Zero Buildings in the Pacific Northwest, Pacific Northwest Economic Region, 2015
- Washington State Energy Code Roadmap, NBI, 2015
- Buildings Modernisation Strategy: Roadmap 2050, Poland and BPIE, 2015
- Roadmap to Zero Emissions, Architecture 2030, 2014
- NASA Net Zero Energy Buildings Roadmap, NREL, 2014
- A Guide to Developing Strategies for Building Energy Renovations, BPIE, 2013
- Strategy Roadmap for Net Zero Energy Buildings in India, USAID, 2011
- Roadmap to Green Government Buildings, USGBC, 2011
- Measurement Science Roadmap for Net-Zero Energy Buildings, NIST, 2010
- Roadmap for a Transformation of Energy Use in Buildings, WBCSD, 2009
- Going the Distance: The Low-Carbon Buildings Roadmap, CBI, 2009
- Roadmap for Positive-Energy and Low-Carbon Buildings and Building Clusters, ADEME
- Better Buildings Through Energy Efficiency: A Roadmap for Europe, Eurima, 2006
- High-performance Commercial Buildings: A Technology Roadmap, US DOE, 2000
- Model Regulation Guidelines: Energy Efficiency and Functional Performance Requirements Based on International Standards, U4E, 2019

Acronyms, abbreviations and units of measure

Acronyms and abbreviations

BEA	Building Efficiency Accelerator
BIPV	building-integrated photovoltaic
BIM	Building Information Modelling
CO_2	carbon dioxide
COP	Conference of the Parties
CHP	combined heat and power
EU	European Union
ESCO	Energy Services Company
EPD	Environmental Product Declaration
HPDs	Health Product Declaration
GBC	Green Building Council
GDP	gross domestic product
GIS	geographic information system
GHG	greenhouse gas
GlobalABC	Global Alliance for Buildings and Construction
GWP	global warming potential
IEA	International Energy Agency
IPEEC	International Partnership for Energy Efficiency Cooperation
LEED	Leadership in Energy and Environmental Design
LCA	life-cycle assessment
MEPS	minimum energy performance standards
NDC	nationally determined contribution
NGO	non-governmental organisation
OTTV	overall thermal transfer value
O&M	operations and maintenance
PACE	Property Assessed Clean Energy
PV	photovoltaic
R&D	research and development
SDG	Sustainable Development Goal
SDS	Sustainable Development Scenario
SSL	solid-state lighting
SHGC	solar heat gain coefficient

UNFCCC	United Nations Framework Convention on Climate Change
UN	United Nations
USD	United States dollar
VAT	value-added tax
WBCSD	World Business Council for Sustainable Development

Units of measure

EJ	exajoule
$GtCO_2$	gigatonne of carbon dioxide
$MtCO_2$	million tonnes of carbon dioxide
kg/m^2	kilogramme per square metre
kWh	kilowatt hour
kWh/m^2	kilowatt hour per square metre
m^2	square metre
tCO_2	tonne of carbon dioxide
TWh	terawatt hour
W	watt
W/mk	watt per meter per degree kelvin
W/W	watts per watt
Mtoe	million tonnes of oil equivalent

Annex

Annex A: *List of stakeholder engagement events and breakdown of stakeholders consulted for the Asia Roadmap*

This roadmap was the product of multiple workshops, webinars, surveying and conversations with experts across Asia, and included the views of over 200 people. The in-person events that have taken place and specifically gathered Asia Roadmap inputs are listed below:

- Singapore-IEA Regional Training on Green Buildings in Singapore, July 2019
- GlobalABC Regional Roundtable for Asia Pacific in Bangkok, Thailand, September 2019

Figure 41 • Participants to the Asia Roadmap process