Roadmap for Energy-Efficient Buildings and Construction in ASEAN

Timelines and actions towards net zero-carbon buildings and construction

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Abstract

The buildings sector plays a key role in decarbonising the global economy. In the Association of Southeast Asian Nations (ASEAN), buildings account for close to a quarter of the region's total final energy consumption and energy-related CO_2 emissions. With continued economic development, urbanisation and population growth across the region, the International Energy Agency's (IEA) analysis shows that both final energy consumption and CO_2 emissions in buildings will continue to grow without ambitious policy actions. Improving the energy efficiency of building envelopes and systems, increasing renewable energy utilisation, phasing out the use of traditional biomass and switching to clean cooking and electricity, while enhancing energy access for vulnerable households across the region, can result in more than a 60% reduction in CO_2 emissions from buildings by 2040 in relation to 2020, and provide many other benefits to households, society and governments.

The Roadmap for Energy-Efficient Buildings and Construction in ASEAN focuses on the policy tools available for ASEAN Member States to drive energy efficiency improvements in the building sector to help meet growing needs for residential and non-residential floor space and energy services, while limiting the growth in energy demand and related emissions. It identifies key energy-efficient and low-carbon actions and activities that governments could consider for implementation by 2025, 2030 and beyond, moving towards net zero-carbon buildings.

Acknowledgements, contributors and credits

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The report builds on the work of the Global Alliance for Buildings and Construction (GlobalABC), International Energy Agency (IEA) and United Nations Environment Programme's (UNEP) Regional Roadmap for Buildings and Construction in Asia (2020) and was prepared by the Energy Efficiency Division (EEFD) of the Directorate of Energy Markets and Security of the IEA with support from the Energy and Minerals Division of ASEC and Renewable Energy and Energy Efficiency and Conservation Department of ACE.

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Executive summary

Buildings represent around 37% of global energy use and energy-related CO_2 emissions for their operation and when the production of materials used for their construction are taken into account.

To meet the Paris Agreement's goal of keeping global temperature increase to well below 2°C, the global economy should aim to achieve net zero CO_2 emissions by 2050. The 2021 IEA report, Net Zero by 2050: A Roadmap for the Global Energy Sector (hereafter, Net Zero by 2050), illustrates "a cost-effective and economically productive pathway, resulting in a clean, dynamic and resilient energy economy dominated by renewables like solar and wind instead of fossil fuels". This pathway outlines a transition to a net zero energy system by 2050 while ensuring stable and affordable energy supplies, providing universal energy access and enabling robust economic growth across different sectors.

The buildings sector plays a key role in decarbonising the global economy. The Net Zero by 2050 report estimates the potential to reduce 97% of this sector's direct CO_2 emissions by 2050, despite the sector's activity more than doubling through growing floor area, expanding access to energy services and increasing living standards. This becomes possible through the transition to zero-carbon-ready buildings – highly energy-efficient buildings that either use renewable energy directly, or rely on a source of energy supply that can be fully decarbonised, such as electricity or district energy. Energy efficiency improvements and electrification can drive a 70% reduction in buildings-related emissions through to 2050, with the remaining reduction coming from behaviour change and on-site renewables.

The purpose of this Roadmap is to identify possible energy-efficient and low-carbon actions and activities that ASEAN Member States (AMS) could consider for implementation by 2025, 2030 and beyond, moving towards net zero-carbon emission buildings. These actions are based on a review of the current buildings sector at the regional level across the seven action areas set out below. While the Roadmap follows the vison of transitioning towards net zero-carbon buildings (in line with the Net Zero by 2050 report), it also acknowledges that different member states have varying national circumstances, targets and priorities in relation to energy-efficient and low-carbon buildings, and each will be configuring its own unique path and pace for the improvements in the buildings sector.

In this Roadmap, net zero-carbon buildings are understood as highly energy-efficient buildings, in which CO_2 emissions from all operational energy consumed over the course of a year are balanced out to reach zero through renewable and/or other zero-emission energy supply.[1] The Roadmap also outlines possible actions that can reduce emissions associated with building materials that could be considered for the transition towards whole life cycle, net zero-carbon buildings. The Roadmap presents a wide range of policy options that governments could choose from while taking into account their unique context.

This Roadmap should be considered alongside the Roadmap towards Sustainable and Energy-Efficient Space Cooling in ASEAN, which has been developed in parallel. This will ensure that space cooling, as one of the fastest growing electricity-consuming end uses in the region, is approached holistically, including the roles of energy-efficient building fabric, passive design and urban planning and their impacts on sustainable cooling.

Energy efficiency and renewable energy are key in the transition of the ASEAN buildings sector

In 2020, energy consumption in buildings accounted for 23% of total final energy consumption in ASEAN, and 23% of total process and energy-related CO_2 emissions, or 0.4 gigatonnes of CO_2 (Gt CO_2).

The 6th ASEAN Energy Outlook (AEO6) is one of the flagship publications of the ASEAN Member States prepared by the ASEAN Centre for Energy (ACE) to analyse key aspects of energy trends, policies, socio-economic development and environmental issues related to energy in the region up to 2040. AEO6 shows that if the rates of energy efficiency improvement and renewable energy utilisation are maintained along historical patterns,[2] ASEAN's building energy consumption is expected to grow by around 60% by 2030 and by 120% by 2040, while energy efficiency measures could help to mitigate this growth by at least 20%.

The IEA's 2019 Southeast Asia Energy Outlook report estimates that under current policy developments ASEAN's electricity demand for space cooling could quadruple between 2017 and 2040, accompanied by rapidly increasing ownership

[1] In this Roadmap zero-emission energy includes energy from renewables, hydrogen and nuclear sources.
[2] This corresponds to the Baseline Scenario, under which ASEAN Member States' energy systems continue to develop along historical trends, with little effort to meet their national or regional targets on energy efficiency and renewable energy.

of air conditioners from less than 20% to potentially more than 60% in 2040.[3] This is likely to cause considerable strain on power systems and increase in GHG emissions if improvements in buildings' energy efficiency and power sector decarbonisation are not implemented.

The ASEAN Plan of Action for Energy Cooperation (APAEC) Phase II: 2021-2025 (APAEC Phase II) sets out a goal for the AMS to achieve an energy intensity reduction target of 32% by 2025 based on the 2005 level. In the APAEC Phase II, buildings are considered a key sector to support the transition, alongside the goal to achieve the renewable energy share of 23% in total primary energy supply (TPES) and renewable energy share of 35% in power generation by 2025. Buildings can contribute through on-site renewable energy generation.

To meet the goals of APAEC Phase II, ASEAN's buildings will need to become highly energy-efficient and use primarily zero-carbon energy sources.

Policy development and investment will drive progress towards net zero-carbon

Investing in energy-efficient and low-carbon buildings is a cost-effective way to reduce emissions and the use of fossil fuels, improve air quality and provide many other benefits to households, society and governments. However, a significant scale-up in investment and changes in regulations will help to unlock these potential benefits in ASEAN. The International Finance Corporation's (IFC) 2019 report on Green Buildings outlines how investment opportunities in green buildings are estimated at USD 17.8 trillion in East Asia and the Pacific and South Asia, representing over 70% of the global total.

Yet, the investment potential remains largely untapped. The status of net zero and low-carbon buildings and the related building energy performance policies and priorities vary greatly across the region, though most AMS have high-level strategies and targets in place for buildings' energy efficiency. A number of AMS have made progress in developing building energy codes and/or building standards, however, they are not always mandatory and often cover only part of the buildings sector, for example large non-residential buildings. This partial coverage substantially limits their impact on the overall improvement of the buildings sector's energy performance. Given that building energy codes typically

[3] These results are for the Stated Policies Scenario that assesses where today's policy frameworks and ambitions, plus continued evolution of known technologies, might take Southeast Asia's energy sector in the period to 2040. This scenario only takes into account policies that have been announced ("stated") and does not take a position on how these policies might evolve in future (IEA 2019a).

focus on new buildings, the energy performance of existing buildings or of those undergoing major renovation is often not covered by energy efficiency regulation.

Within the ASEAN region, there are ongoing efforts towards regional harmonisation of Minimum Energy Performance Standards (MEPS) for appliances and equipment, which could further enable energy efficiency improvements in the buildings sector. In addition, the Sustainable ASEAN Energy Management Training and Certification Scheme provides certification for energy managers and the Energy Management Gold Standard – for energy-intensive organisation (building and industry).

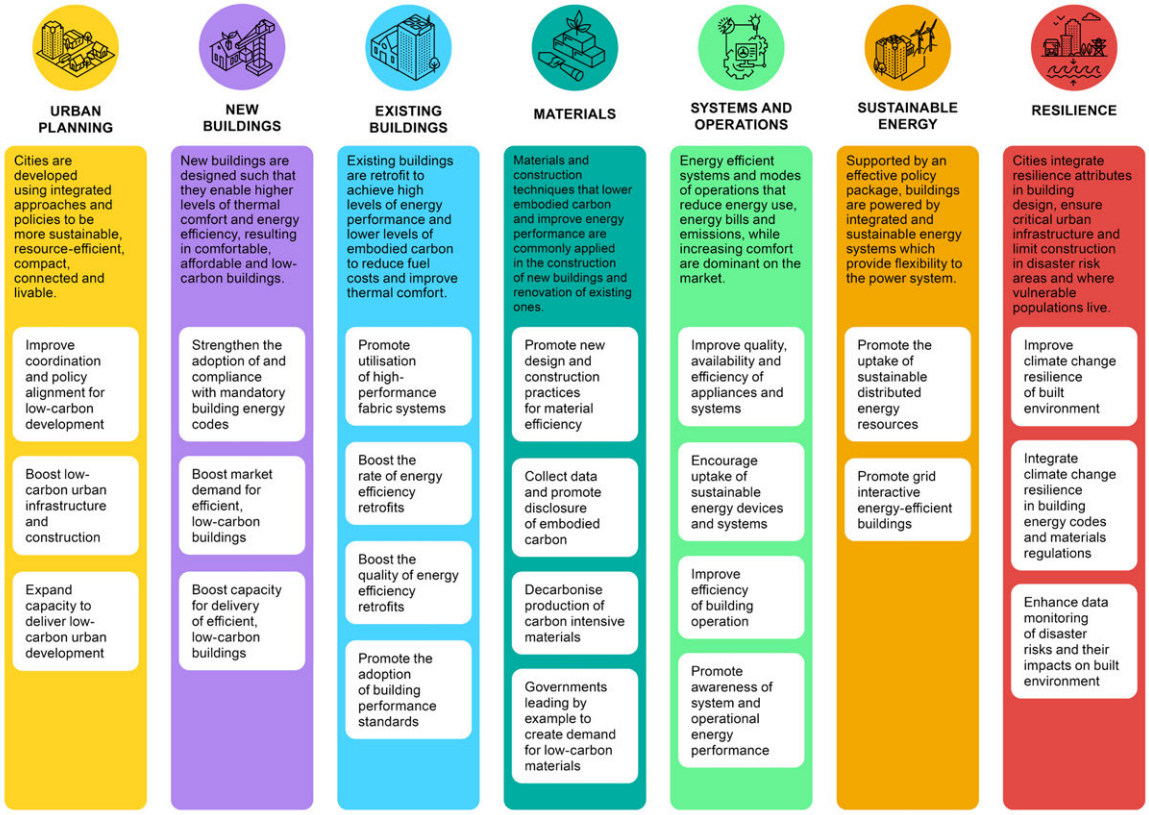
Transition towards net zero-carbon buildings offers multiple benefits

Transitioning to a net zero-carbon buildings sector in ASEAN offers multiple benefits beyond energy savings and emissions reductions. By considering multiple benefits, policy makers can tap into several policy areas that can support various societal goals. For example, energy efficiency improvements and renewable energy utilisation in buildings result in lower air pollution and corresponding health improvements. Efficient building envelopes, systems and appliances lower energy bills for households and businesses, while providing required thermal comfort and indoor air quality. Improved building fabric can further reduce heat exposure for building occupants resulting in better health and increased productivity. Energy efficiency also offers job creation potential in high-performance building construction and building operation management, as well as improvements in energy system security and resilience.

The Roadmap paves the way towards net zero-carbon buildings

This Roadmap for Energy-Efficient Buildings and Construction in ASEAN identifies timelines, milestones, actions and activities across seven ‘action areas’**.** Each of these areas provides a structure that includes a vision, as well as options for actions and activities to support the transition to net zero-carbon buildings and construction.

Roadmap vision and actions for each action area



Each action area of the Roadmap can be read either in isolation or in conjunction with other parts of the document, depending on the national priorities and resources available for implementation.

While working with this Roadmap it is important to keep in mind several overarching principles:

- **Adaptability** – this Roadmap is intended as guidance, not as prescription. The AMS, with their in-depth knowledge of the specific local context, have an opportunity to configure an effective implementation plan based on the Roadmap.
- **Holistic approach** – the buildings sector is complex and fragmented. This Roadmap suggests maintaining an integrated view of the sector.
- **Strategic planning** – actions outlined in the Roadmap are likely to have a higher impact if they are integrated into existing policy processes and strategic plans, or into newly developed ones.
- **Multi-stakeholder collaboration** – effective communication channels and coordination mechanisms between national, subnational and local governments, as well as the involvement of various stakeholder groups, are important for effective implementation of this Roadmap.

The following steps could support the AMS to identify context-specific options for actions to achieve higher levels of energy and carbon performance of buildings in their national context:

- assessing the context, existing policy environment, socio-economic and other factors relevant to the buildings sector
- defining institutional configuration with the appointment of a responsible governmental entity to lead the implementation process and other institutions that could be involved in the process
- establishing a stakeholder engagement process in order to identify priority actions for the buildings sector, taking into account diverse interests of various stakeholder groups
- developing an implementation plan that sets out actions, activities, responsibilities and timelines, taking into account level of effort, expected impacts and required resources
- establishing an indicator and data collection framework for monitoring and progress tracking.

Key recommendations of the Roadmap

This section outlines key recommendations across seven action areas that constitute a possible policy package to support transition towards more energy efficient and low-carbon buildings.

An effective policy package covers all seven action areas described above and includes a combination of regulations, incentives and information policy instruments.[4]

An extensive list of potential policy instruments available to the AMS to support progress on energy-efficient and low-carbon buildings is outlined in this Roadmap. A combination of policy actions is needed to constitute a policy package for net zero-carbon buildings in the AMS. This process could begin by setting ambitious, yet achievable, overarching targets for improving energy efficiency, decarbonising the buildings sector and communicating them to key stakeholder groups.

Regulatory policy instruments are critical elements when developing a policy package.

Building energy codes are among the "most widely recognised, scalable" (UNEP, 2018) and effective policy instruments for buildings (Boza-Kiss, Moles-Grueso and Urge-Vorsatz, 2013). They are implemented in over 80 countries. Mandatory

[4] For more guidelines on developing effective policy packages for low-carbon buildings, see the United Nations Environment Programme (UNEP's) Handbook of Sustainable Building Policies, 2013.

MEPS and labels for key appliances and equipment used in buildings are other fundamental policy instruments with proven effectiveness: implemented in over 120 countries around the world, MEPS and labels "have helped more than halve the energy consumption of major appliances in countries with the longest-running programmes" (IEA, 2021d).

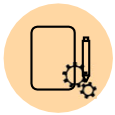
Once regulatory policies are in place, their effective implementation and enforcement could be supported by information policy instruments and incentives to ensure compliance and further progress. Building certification and labelling with ratings based on energy and carbon performance of buildings can provide clear signals for consumers, property developers and other practitioners in the construction industry, to encourage more informed and sustainable choices and practices.

A range of financial and non-financial incentives could be linked to the certification schemes to support the building and construction industry to adapt to the regulation at early stages of adoption, and to help overcome market barriers such as upfront cost and access to capital, as well as to drive action beyond minimum standards.

Finally, capacity building programmes are crucial to ensuring that there are sufficient skills and knowledge on various aspects of net zero-carbon buildings, as well as well an adequate number of local qualified experts and practitioners.

The Association of Southeast Asian Nations (ASEAN), consisting of the 10 AMS, has a great variety of national circumstances in political, economic, environmental and social spheres. This regional Roadmap acknowledges that every AMS has its unique context in the buildings sector and beyond. While the Roadmap offers a comprehensive "menu" of actions, each government can develop a suite of actions and possible approaches suitable to its country context and sufficiently ambitious to follow the pathway towards a net zero- carbon buildings sector. Moreover, the milestones outlined in the Roadmap for policy progress at different points in the future are intended as indicative, and do not suggest a specific commitment for every AMS.

Summary policy package towards net zero-carbon buildings in ASEAN

	Policy measure	Description
 Regulation	Building Energy Codes and Building Standards	Minimum energy and thermal performance requirements, renewable energy systems installation or utilisation, maximum allowed amount of embodied carbon emissions, structural and thermal resilience, covering all building types, new and existing buildings.
	Product standards	Mandatory minimum energy performance standards (MEPS) for all types of appliances and building systems that are progressively and regularly updated.
	Procurement regulation	Mandatory requirements for public procurement to use low-carbon materials and highly efficient equipment and appliances; use life-cycle approach to assess embodied carbon emissions in buildings' materials.
	Regulation on materials	Mandatory protocols for buildings' deconstruction, plans and systems for collection and reuse/recycling of construction and demolition waste.
	Framework regulations	Electricity regulation that supports decentralised production, selling to the grid, peer-to-peer trading of renewable electricity; phase out of fossil fuel subsidies; mandatory requirements for integration of renewables into urban planning.
 Information	Certification	Certification of energy and carbon performance for new and existing buildings with requirements for materials efficiency, use of low-embodied-carbon materials.
	Labelling	Mandatory rating labels for new and existing buildings based on energy and carbon performance (including materials and systems); harmonised testing.
	Disclosure and benchmarking	Mandatory disclosure and benchmarking schemes for energy and carbon performance for new construction and large renovation projects.
	Training programmes	Integrated policy portfolios towards net zero-carbon solutions for net zero- carbon buildings; Life-cycle analysis of embodied carbon emissions and ways to reduce them; use of low-carbon materials; benefits of and solutions for energy-efficient home improvements.
	Education programmes	Accreditation systems for professionals on low-carbon construction, renovation, building energy management; related curricular for all levels of education.
	Awareness raising	Awareness raising programmes for consumers on multiple benefits of efficient and low-carbon buildings, energy-efficient renovation policies and incentives.
	Digital tools and data	Integrated design tools to assess energy performance and embodied carbon for building construction or renovation, building energy management systems.
 Incentives	Financial incentives	Grants, preferential loans, tax rebates, tied to energy and carbon performance levels of new or renovated buildings, building materials, systems and appliances.
	Non-financial incentives	Expedited development review and approvals, fee reductions, density bonuses and development allowances for energy-efficient low-carbon buildings.
	Tariff policies	Reflective energy pricing and preferential tariffs for renewable energy, especially that produced through distributed energy sources.

Note: Highlighted areas in the table could be considered as potential starting points for establishing a policy packages for buildings.

The ASEAN context for the Roadmap's development

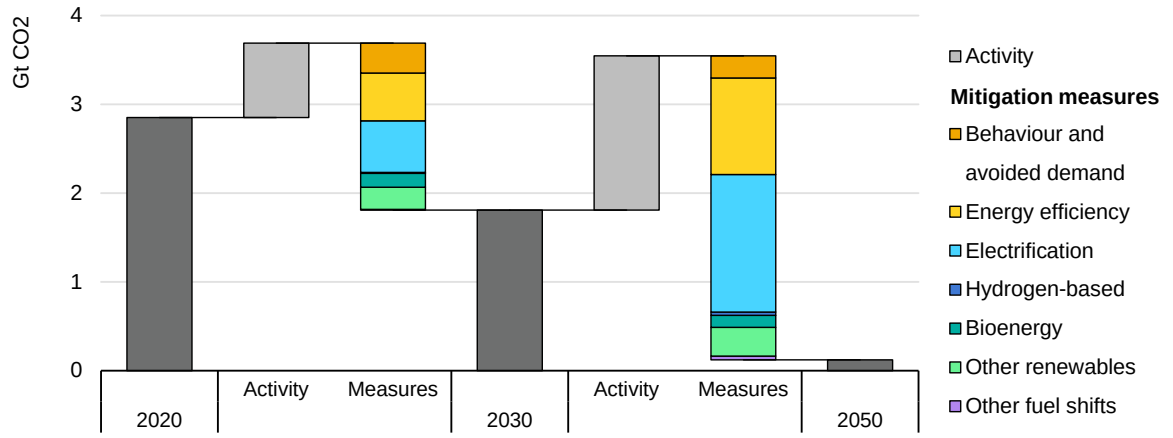
Over its lifetime, a building's CO_2 emissions footprint consists of the embodied CO_2 emitted from the manufacturing and processing of building materials and construction, as well as the operational CO_2 emissions from the energy used during its operation, and finally also CO_2 emissions from its decommissioning and demolition.

CO_2 emissions from energy-related buildings operations and construction material production account for around 37% of global energy-related emissions (IEA, 2021a).

To meet the Paris Agreement's goal of keeping the global temperature increase to well below 2°C, the global economy should aim to achieve net zero CO_2 emissions by 2050. The IEA Net Zero by 2050 report (IEA, 2021b) illustrates "a cost-effective and economically productive pathway, resulting in a clean, dynamic and resilient energy economy dominated by renewables like solar and wind instead of fossil fuels". This pathway, reflected in the Net Zero Emissions by 2050 Scenario, outlines a transition to a net zero energy system by 2050 while ensuring stable and affordable energy supplies, providing universal energy access and enabling robust economic growth across different

The Net Zero by 2050 report shows that although building activity more than doubles by 2050 with new floor area being added, energy access expanding and living standards increasing, emissions fall as a result of reducing energy demand through energy efficiency improvements, behavioural change and electrification. The net zero emissions scenario suggests that, by undertaking these efforts, it could be possible to nearly eliminate CO_2 emissions from the buildings sector operations by 2050.

Global direct CO_2 emissions reductions through mitigation measures in the buildings sector in the net zero energy scenario



Notes: Activity = change in energy service demand related to increasing population, increased floor area and income per capita. Behaviour = change in energy service demand from user decisions, e.g. changing indoor temperature settings. Avoided demand = change in energy service demand from technology developments, e.g. digitalisation.

Source: IEA (2021b), Net Zero by 2050.

The alignment of the building and construction sector with the Paris Agreement goals of decarbonising, improving access and use of sustainable energy[5] requires a combination of measures, such as: sustainable planning, improvements in building energy performance including efficient design, highly efficient systems and their operations, increasing efficiency of material production and their use, and improving access to sustainable energy at both the building and grid levels.

This Roadmap aims to support the objectives of the ASEAN Plan of Action for Energy Cooperation (APAEC) Phase II: 2021-2025, which are to carry out market transformation initiatives in favour of energy-efficient technologies in the buildings, transport and industry sectors to achieve the 32% energy intensity reduction target by 2025 based on 2005 levels (ACE, 2020). In APAEC Phase II, buildings are considered a key sector to support the transition, alongside a renewable energy share of 23% in total primary energy supply (TPES) and renewable energy share of 35% in power generation by 2025 (ACE, 2020), to which buildings can contribute through on-site renewable energy generation.

About this Roadmap

In late 2020, the Association of Southeast Asian Nations (ASEAN) commissioned the International Energy Agency (IEA) to deliver the Roadmaps Towards Sustainable and Energy-Efficient Buildings and Cooling in ASEAN project. The

[5] In this Roadmap we understand 'sustainable energy' in the context of Sustainable Development Goal 7 (SDG7) that covers aspects of energy access, energy efficiency and renewable energy.

project is funded by the ASEAN-Australia Development Cooperation Program Phase II (AADCP II) and supported by the ASEAN Secretariat (ASEC), Energy Efficiency Sub-Sector and Conservation Network (EE&C-SSN) and the ASEAN Centre for Energy (ACE).

This project forms part of the ASEAN Plan of Action for Energy Cooperation (APAEC) Phase II 2021-2025. It will deliver Action Plan 3.1 to develop and disseminate the Sustainable and Energy-Efficient Buildings and Cooling Roadmaps for ASEAN under Outcome-based Strategies for Energy Efficiency and Conservation 2021-2025, while supporting the overall objective of the APAEC to reduce energy intensity by 32% in 2025 compared to 2005 levels.

The project aims to help address increasing energy demand and emissions in ASEAN and improve collaboration between stakeholders in the region, by developing and delivering the following:

- the present publication entitled Roadmap for Energy-Efficient Buildings and Construction in ASEAN
- a parallel publication entitled Roadmap Towards Sustainable and Energy-Efficient Space Cooling in ASEAN
- capacity building webinar series on cooling and buildings
- series of stakeholder consultation workshops.

The project's outputs are intended to support policy makers in developing, adopting, and enforcing energy efficiency policies and programmes. This project also provides milestones for the short-term (2025), mid-term (2030) and long-term (net zero-carbon). These milestones and timelines are not intended to represent the views of the AMS, but to provide future milestones towards an energy-efficient, low-carbon and eventually net zero-carbon buildings sector in the region.

There are a number of design and technological options available to keep buildings cool, including: building design, orientation, choice of building fabric, shading and natural ventilation. Trees and green spaces in urban environments can also provide shade to buildings while reducing the urban heat island effect. While these features are important components of sustainable space cooling, this Roadmap primarily focuses on equipment within the buildings, namely air conditioning and fans. However, the Roadmap Towards Sustainable and Energy-Efficient Space Cooling in ASEAN developed alongside this report addresses a wider range of considerations that influence sustainable cooling.

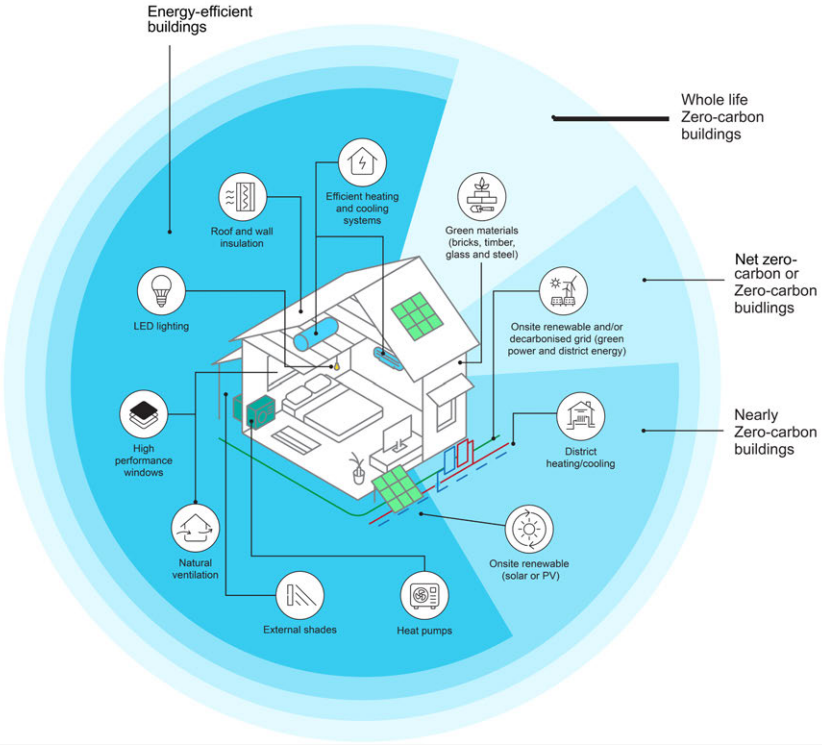
The road to net zero-carbon buildings

The journey towards the net zero-carbon building and construction sector consists of multiple steps. From an operations perspective, the first objective is to ensure

that buildings are constructed and refurbished to a high degree of energy efficiency and are supplied by low-carbon energy (low-carbon). Adding renewable energy (or other zero-emission energy supply) to a highly efficient building offers an ability to reduce (nearly-zero-carbon), neutralise over a defined period of time (net zero-carbon), or eliminate completely the operational carbon emissions (zero-carbon). It is also possible to construct buildings that generate more renewable energy than they consume sending the surplus energy back into a grid (carbon-negative). Each stage is dependent on the availability – and supply – of renewable or decarbonised energy to the building.

To shift buildings and their construction towards full decarbonisation, it is necessary to approach "carbon emissions"[6] from the perspective of the whole life cycle of a building. Achieving this may require a systemic shift in production of materials, and likely the need to rely on carbon offsets for some materials such as concrete and other CO_2 emitting materials.

Different levels of zero-carbon buildings



The Net Zero by 2050 report introduces a concept of a zero-carbon-ready building, which is a building that is "highly energy-efficient and either uses renewable energy directly, or from an energy supply source that can be potentially fully

[6] For the purpose of this Roadmap, building CO_2 emissions are referred to as "carbon emissions".

decarbonised such as electricity or district energy", alongside decarbonised materials. This means that a zero-carbon-ready building can become a zero-carbon emissions building without any further changes to the building envelop or its equipment because it has already achieved high energy performance (IEA, 2021b).

The goal of this Roadmap is to support the vision to transition towards whole life cycle, zero-carbon buildings. However, recognising that different AMS will be at different stages of addressing building and construction sector emissions, and have different levels of resources and capacity for implementation, this Roadmap focuses on actions that support moving towards net zero-carbon buildings, with the zero-carbon buildings being the next step. It also sets out actions that reduce the emissions associated with building materials and that can support achieving the ultimate goal of whole life cycle, net zero-carbon (for simplicity, we will refer to this overall ambition as "net zero-carbon" throughout this Roadmap).

Defining net zero-carbon

There are a number of terms that describe the CO_2 emissions of buildings and construction and they can be applied to different scopes and site boundaries; however, this Roadmap utilises the following definitions*, based on those described in the Net Zero by 2050 report (IEA, 2021b) and the Zero Energy Building Definitions and Policy Activity – an International Review (OECD/IPEEC, 2018). These are:

- **Energy-efficient**: a building with a high degree of energy efficiency in its fabric and building services that consume energy, e.g. heating, cooling, cooking, lighting, ventilation, hot water and appliances
- **Low-carbon**: a building that is energy-efficient (low-energy) and is supplied by low-carbon energy. Some building services equipment may not be capable of decarbonising without being replaced (e.g. fossil gas boilers)
- **Nearly zero-carbon**: a building that is energy-efficient and may have some available zero-emission energy supply (onsite or offsite), but that does not offset 100% of the building's energy demand
- **Net zero-carbon**: a building that is energy-efficient and relies on zero-emission energy sources that meet the energy demand over the course of a year (or another established timeline, e.g. a month)
- **Zero-carbon**: a building that is energy-efficient and has its energy demand completely met through zero-emission energy generated either onsite or offsite
- **Carbon-negative**: an energy-efficient building that generates renewable energy onsite that not only fully covers the building's own energy demand, but also produces excess renewable energy which is fed back into a grid and can be used for other offsite purposes

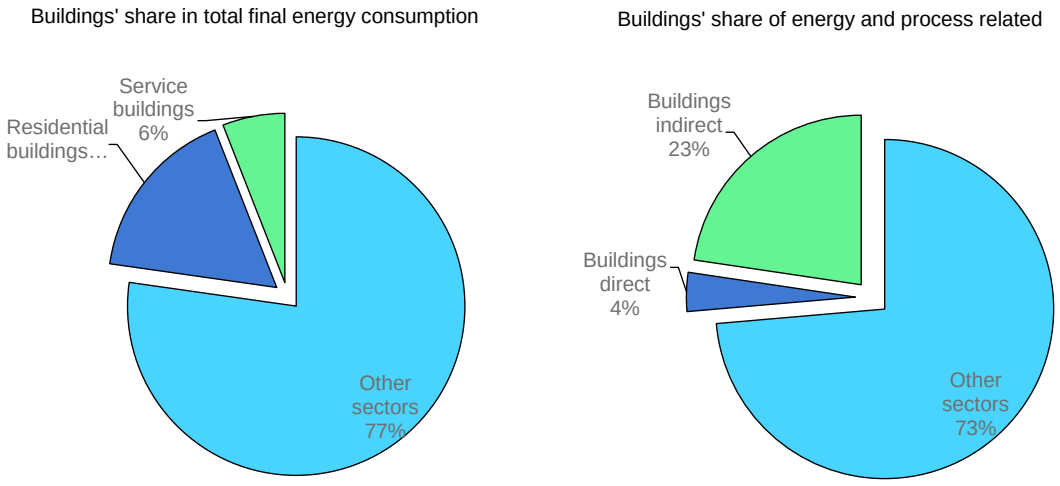
- **Whole life cycle, net zero-carbon**: zero-carbon buildings, in which embodied carbon emissions from the materials used in their construction are decarbonised and/or offset, alongside the operational carbon emissions, over the building's lifetime.

*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 and zero-carbon neighbourhoods, districts or cities.

Energy and emissions trends show need for action

In 2020, buildings accounted for 23% of total final energy consumption in ASEAN (with 17% and 6% for residential and service buildings, respectively), and for 27% of total energy and process-related direct and indirect CO_2 emissions, that amounted to 0.4 Gt CO_2 (IEA, 2021c). In addition, production of construction materials accounted for approximately 11% of emissions globally (IEA, 2020c), making decarbonisation of buildings and construction sectors critical to achieving the goals of the Paris Agreement.

Share of buildings' final energy and CO_2 emissions in ASEAN, in 2018



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

Source: Adapted from IEA (2021c), World Energy Outlook 2021.

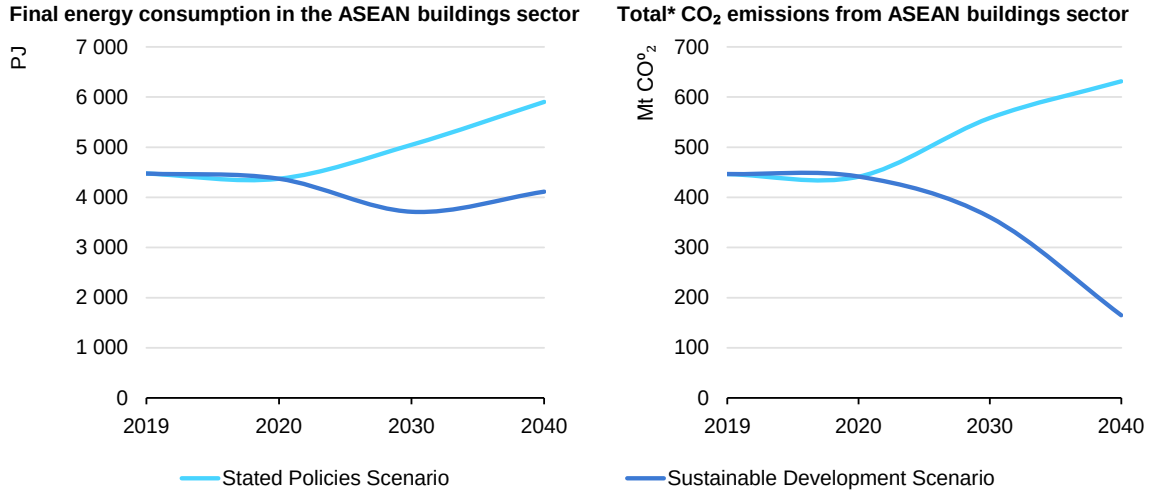
Residential buildings account for the vast majority of the total final energy consumption of the ASEAN buildings sector, while buildings related to services (i.e. non-residential and non-industrial) account for slightly over a quarter of it at 26% (IEA, 2021c).

ACE and the Deutsche Gesellschaft für Internationale Zusammenarbeit (German Society for International Cooperation) (GIZ)'s 6th ASEAN Energy Outlook 2017-2040 (AEO6) baseline scenario, which sees strong growth in floor space and consumer demand, estimates that ASEAN's economy-wide total final energy consumption (TFEC) will grow by two-thirds by 2030 from 2017, and by 120% by 2040. However, achievement of the existing national and regional targets on energy efficiency and renewable energy could limit this growth to less than one-third by 2030, and to less than 50% by 2040 (ACE & GIZ, 2020).

IEA's analysis shows (see figure below) that both final energy consumption and CO_2 emissions in buildings will continue to grow without ambitious policy actions (under the Stated Policies Scenario).[7] Achievement of the energy-related targets of the Sustainable Development Goals (SDGs) at the regional level (under the Sustainable Development Scenario)[8] and adopting appropriate energy efficiency policies and technologies will allow for offsetting most of the growth in energy consumption, while providing energy access for all. Improving the energy efficiency of building envelopes and systems, increasing renewable energy utilisation from on-site and offsite sources, phasing out the use of traditional biomass and switching to clean cooking and electricity, while enhancing the energy access of vulnerable households across the region, can result in more than a 60% reduction in CO_2 emissions from buildings by 2040 from the 2020 levels (IEA, 2021c). The analysis also shows that achieving energy-related SDGs is not going to be sufficient for transitioning the region's buildings sector to the net zero-carbon level and that more ambitious actions will be required in order to reach this goal.

[7] The Stated Policies Scenario assesses where today's policy frameworks and ambitions, plus continued evolution of known technologies, might take Southeast Asia's energy sector in the period to 2040. It only takes into account policies that have been announced ("stated") and does not take a position on how these policies might evolve in the future (IEA 2019c).
[8] The Sustainable Development Scenario presumes the achievement of the key energy-related components of the United Nations Sustainable Development Goals: delivering on the Paris Agreement, achieving universal access to modern energy by 2030 and dramatically reducing energy-related air pollution.

Final energy consumption and CO_2 emissions of the ASEAN buildings sector



*Total emissions are comprised of direct and indirect emissions. Direct emissions include those from coal, oil and natural gas. Indirect emissions are the emissions from power generation plants.

Note: In this figure, "buildings" energy use and emissions refer to the operational energy consumption, and do not include the construction phase or the energy and emissions associated with the manufacture of materials.

Source: Adapted from IEA (2021c), World Energy Outlook 2021.

With 9% of the global population, ASEAN has relatively low CO_2 emissions per capita: at 3.9 tonnes of CO_2 per capita (tCO_2/capita) compared to 12.1 tCO_2/capita in North America and 5.8 tCO_2/capita in Europe (IEA, 2020a).

Population growth, urbanisation and changes in lifestyle, enabled by increasing incomes, are driving the increase in demand for energy-consuming services and products, as well as construction materials related CO_2 emissions. The population is expected to grow by over 100 million by 2040 from a current population of 620 million (UN, 2019), with growth concentrated in Indonesia, the Philippines and Viet Nam.

The rate of urbanisation is expected to continue to increase from 50% in 2018 to approximately 60% by 2040, adding another 120 million urban dwellers, and resulting in an estimated increase in floor area by 60% from today (GlobalABC/IEA/UNEP, 2019). This is likely to continue creating demand for materials such as steel, cement, glass and aluminium, particularly as the need for more floor area in cities is often met by medium- and high-rise buildings, a large share of which is supplied by construction materials through unregulated markets.

The AMS are facing increasing pressure on their urban areas due to existing and changing structures of informal settlements (e.g. slums or temporary encampments). It is estimated that more than 95 million people in the region live in urban slums (UN ESCAP and UNEP, 2021). Slums and informal settlements across the region take various forms and are characterised by different levels of poverty, configuration of the built environment and infrastructure. However,

challenges in accessing reliable and sustainable energy services and implementing building standards effectively are common for urban slums in many ASEAN cities. Taking actions on addressing the issue of slums and enhancing their dwellers' access to basic services, including energy, offer a great opportunity to proceed in an efficient and low-carbon way in order to offset some of the expected increase in the region's energy demand.

GDP is also expected to continue to rise, with Singapore and Brunei Darussalam demonstrating the highest GDP per capita growth rates in ASEAN by 2040. Significant growth is expected in Malaysia, Thailand and Indonesia, followed by Viet Nam and the Philippines, while Cambodia, Lao People's Democratic Republic (PDR) and Myanmar are expected to experience more modest increases.

With its currently high reliance on fossil fuels, constituting almost 80% of electricity production, a growing energy demand and a small share of modern renewables on the region's energy mix, the achievement of SDG 7 by 2030 remains a challenging task for ASEAN (UN ESCAP, 2021a).

Access to electricity has been steadily growing in ASEAN, having reached 96% of the region's population in 2019 (up from 79% in 2000) (UN ESCAP, 2021b). Progress on clean cooking remains limited, with only 68% of the region's population in 2019 being able to access clean cooking fuels and technologies. Increasing utilisation of modern renewable energy (excluding the use of traditional biomass) is another area which needs to be addressed, as in 2019 the regional share for it was quite modest at 12% of TFEC.

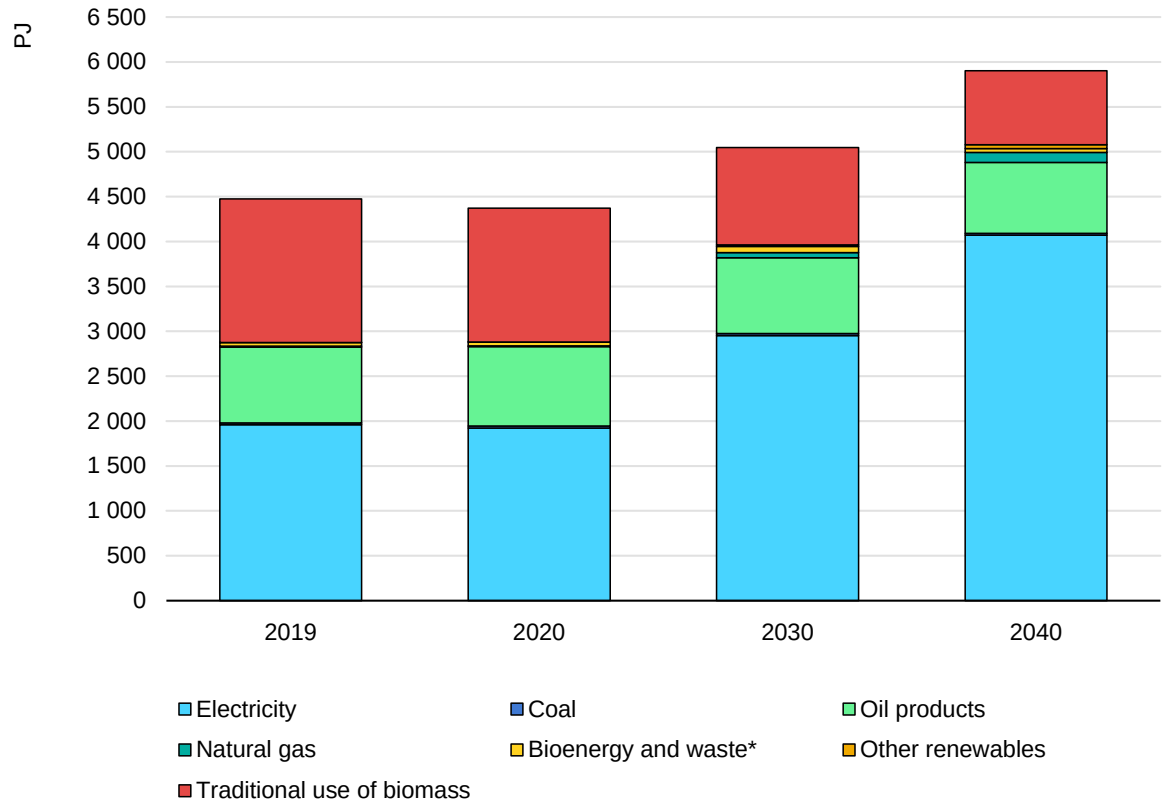
Improvement in the region's levels of energy efficiency, as measured through the primary energy intensity, has been showing some progress. In 2018, energy intensity was 3.7 megajoules (MJ) per one 2011 USD purchasing price parity (PPP) in 2018, down from 5.3 in 2000, which is lower than the global average (4.6 MJ per 2011 PPP USD in 2018). However, the compound rate of primary energy intensity (a proxy indicator used for tracking improvements in energy efficiency) in the region has been fluctuating significantly during the past decade, influenced by various structural factors and the economic situation in different countries (UN ESCAP, 2021c).

Efficient and low-carbon energy use in buildings is key

Current final energy consumption in buildings is primarily from electricity (generated from mostly fossil fuels), traditional use of biomass and oil products. Current policy actions (under the Stated Policies Scenario) are expected to result in almost halving the amount of traditional biomass used in buildings by 2040,

which will still account for 14% of TFEC in ASEAN's buildings in 2040 (IEA, 2021c). Further, policy actions promoting utilisation of low-carbon energy sources, efficient and clean technologies in buildings, especially for cooking and heating, could help to substantially reduce this share and increase the use of modern renewables. Electricity use in buildings demonstrates a significant growth of 108% by 2040 over 2019. Increased utilisation of distributed renewable energy sources is a promising solution for the buildings sector to reduce GHG emissions associated with the increasing electricity demand.

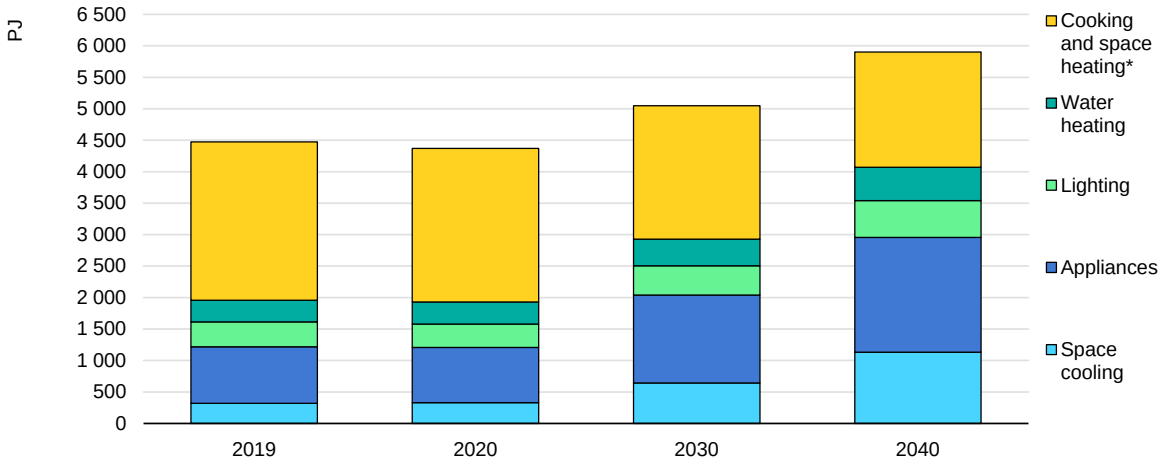
Final energy consumption of ASEAN buildings by fuel type



* "Bioenergy and waste" excludes the use of traditional biomass.
Source: Adapted from IEA (2021c), World Energy Outlook 2021 .

Energy demand is expected to grow among all the end uses by 2040 (with the exception of cooking and heating due to decreasing use of traditional biomass). Space cooling is among the fastest growing end uses, as its energy consumption is expected to more than triple by 2040, followed by appliances for which doubling of energy consumption is estimated within the same period.

Final energy consumption of ASEAN buildings by end use



* Use of traditional biomass is included in the cooking and space heating category.
Source: Adapted from IEA (2021c), World Energy Outlook 2021, based on data for Stated Policies Scenario.

Cooking is the next largest energy end use in ASEAN buildings. In 2018, 208 million people in the region lacked access to clean cooking (UN ESCAP, 2021d). The overall trend is towards replacement of traditional biomass with LPG and electrical cookers for the provision of clean cooking. However, the use of traditional biomass is still very common, especially in rural areas. In 2018, around 74% of residential cooking in ASEAN used traditional biomass sources, with wood as the most common fuel, and without substantial policy interventions the high share of biomass is expected to stay relatively steady through 2040 (ACE & GIZ, 2020).

Increasing energy demand across buildings' end uses and the expected continued heavy reliance on fossil fuels and traditional biomass emphasise the importance, not only of improvements in the energy performance of building envelopes to reduce the overall energy needs, but also of increased efficiency of energy-consuming systems and decarbonisation of buildings' energy supply.

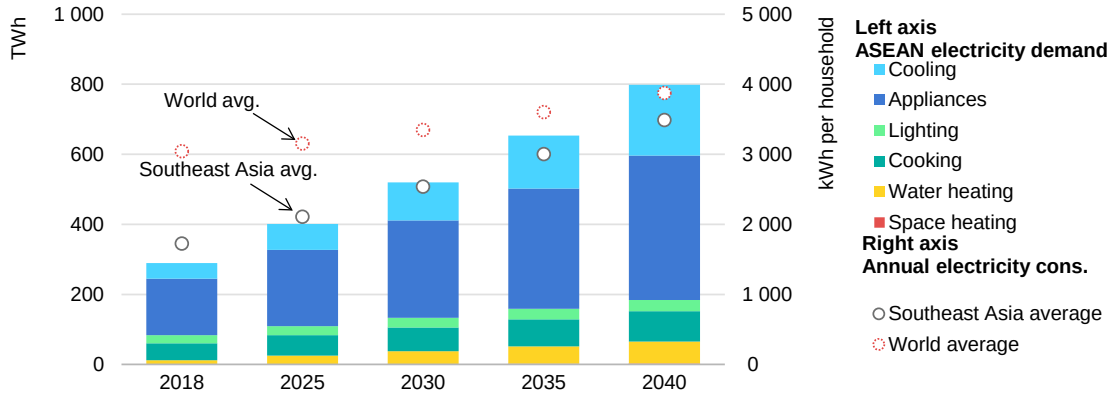
Need for thermal comfort and increasing temperatures are driving electricity demand

As GDP, incomes and electrification grow, so will the demand for comfort cooling, driving the ownership of air conditioners, fans, dehumidifiers and other cooling equipment upwards. The ASEAN region is amongst the warmest and most humid in the world, with consequently very high Cooling Degree Days, which can serve as a measure for the potential need for space cooling.

According to the IEA's analysis (under the Stated Policies Scenario), the ownership of air conditioners in the ASEAN region is estimated to increase from

less than 20% in 2017, to potentially more than 60% in 2040. This may cause considerable strain on power systems, and increase related GHG emissions. As a result, the electricity demand for space cooling would grow from 88 TWh in 2019 to 314 TWh by 2040 (IEA, 2021c). Due to ASEAN's seasonal profile, cooling is also estimated to account for almost 30% of its peak electricity demand by 2040, up from around 10% in 2017, representing the need for about 150 GW of additional generation capacity to meet the peak demand (IEA, 2019a).

Electricity demand for ASEAN residential end uses



Notes: TWh= terawatt-hours; kWh = kilowatt-hour. Appliances include large appliances such as refrigerators, freezers, washing machines, clothes dryers, dishwashers and small appliances such as televisions and microwaves. Penetration rates for basic appliances like refrigerators are already high.

Source: IEA (2019b), The Future of Cooling in Southeast Asia.

In the absence of other solutions (passive cooling, building envelope efficiency, natural ventilation, etc.), it is estimated that a large share (40%) of the region's population will still lack access to comfort cooling, and consequently remain at risk of heat stress (IEA, 2019b). Cooling needs will also reinforce the importance of urban design, nature-based solutions, passive cooling, district cooling and white and green roofs, among others.

Solutions which address issues around demand response and flexibility of energy loads to limit strains on the system due to peaks in demand, and around adapting construction practices to minimise the use of carbon-intensive materials such as steel and cement, are becoming particularly important. Decarbonisation of the overall power system needs to increase rapidly and to play a major role in the transition of the buildings sector towards the net zero-carbon.

The IEA estimates that for ASEAN the decarbonisation of the electricity sector will represent over 30% of the CO_2 emissions reductions by 2040 needed under the Sustainable Development Scenario that presumes delivering on the Paris

Agreement, achieving universal access to modern energy by 2030 and dramatically reducing energy-related air pollution (IEA, 2019c).

The green building market needs investments at scale

Investing in zero-emission, efficient and resilient buildings is a cost-effective way to reduce carbon emissions, improve air quality and contribute to many other benefits to households, society and governments (IFC, 2016). A significant scale-up in investment and changes in regulations will help unlock these potential benefits. According to a Green Building Investment study by the IFC, the investment opportunities in green buildings are estimated at USD 17.8 trillion in the East Asia Pacific and South Asia, representing over 70% of the global total (IFC, 2019).

Yet, despite these numerous benefits, the investment opportunities remain largely untapped. Many economies, especially in developing Asia, are prioritising other urgent energy policy issues such as energy access, resilient networks and security of supply, which are critical to enabling a modern energy system. However, a number of countries also have fossil subsidies in place for both producers and consumers. In South Asia and Southeast Asia, for instance, these subsidies risk distorting the market for low-carbon investment decisions (Evan, 2017). 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.

An enabling policy framework for investment and finance will offer an opportunity to mobilise and effectively channel finance to investments in 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. Examples may include: establishing effective incentives, green financing frameworks (e.g. green bond frameworks, environmental and social management systems, and environmental, social and governance (ESG) reporting), and financing mechanisms such as dedicated funds utilising blended finance structures and lending schemes. Throughout this Roadmap, regulatory and financial tools will be described that can enable the implementation of actions to stimulate a market transformation.

Policies and initiatives vary across the region

Regulatory policy instruments are critical elements when developing a policy package. Building energy codes are among the "most widely recognised, scalable"

(UNEP, 2018) and effective policy instruments for buildings (Boza-Kiss, Moles-Grueso and Urge-Vorsatz, 2013). They are implemented in over 80 countries . Mandatory MEPS and labels for key appliances and equipment used in buildings are other fundamental policy instruments with proven effectiveness: implemented in over 120 countries around the world, MEPS and labels "have helped more than halve the energy consumption of major appliances in countries with the longest-running programmes" (IEA, 2021d).

The status of low- and zero-carbon buildings and building energy performance policies varies greatly across the region. While most countries have high-level strategies and targets in place for building energy efficiency, the level of policy development for improving energy efficiency in buildings differs across the AMS.

At the regional level, there are ongoing efforts towards harmonisation of Minimum Energy Performance Standards (MEPS) for appliances and equipment, which could further enable energy efficiency improvements in the buildings sector across the region. In addition, the Sustainable ASEAN Energy Management Training and Certification Scheme provides certification for energy managers, and the Energy Management Gold Standard provides certification for energy-intensive organisations (building and industry).

Several countries, including Malaysia and Singapore, have had building codes and standards for many years, which are complemented by subsidy schemes and other incentive mechanisms, many in the form of tax incentives. Some have developed building codes more recently, and others are still in the process of developing them (see New Buildings section).

Almost all countries within Asia have reported Nationally Determined Contributions (NDCs), the process by which countries announce their national-level commitments to reduce carbon emissions under the Paris Agreement in the context of the United Nations Framework Convention on Climate Change (UNFCCC). 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. This Roadmap aims to support the AMS in their NDC development by providing an illustration of the pathway towards a net zero-carbon, efficient and resilient building stock.

Several initiatives are underway at national and regional levels that are targeting emissions reductions from the buildings sector, and energy efficiency of gains in buildings and/or appliances. In order to strengthen and align this Roadmap with other related initiatives, input and feedback were sought from these initiatives and others where relevant and possible.

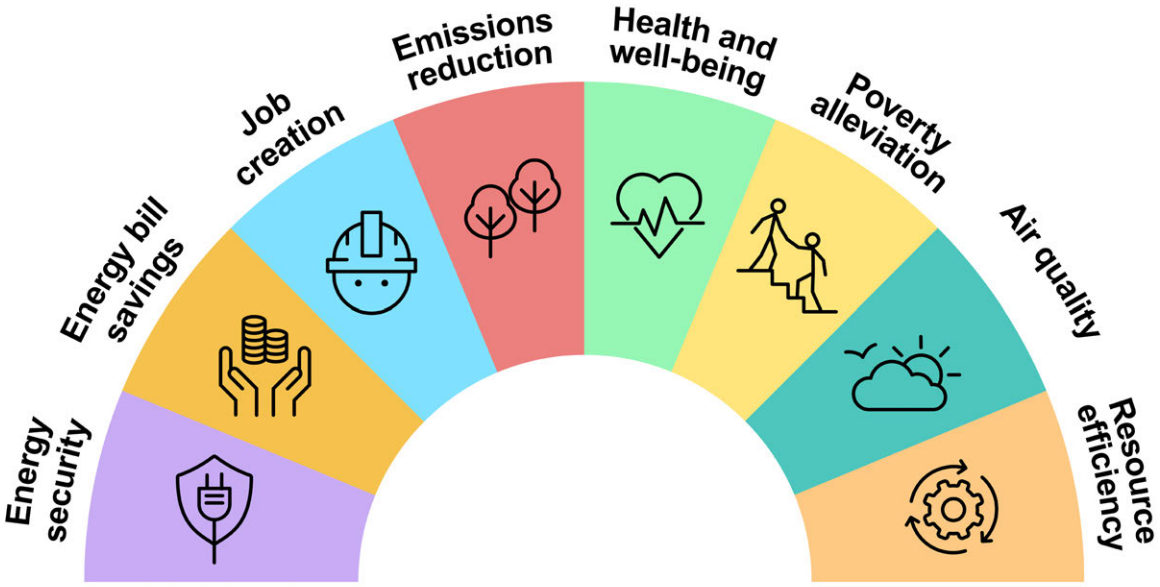
In addition, a range of initiatives that complement the objectives of this Roadmap for the region includes:

- NDC Roadmap for a Low-Carbon, Climate-Resilient Buildings and Construction Sector in Viet Nam, by the Programme for Energy Efficiency in Buildings (PEEB) and the Ministry of Construction of Viet Nam
- Roadmap for Buildings and Construction in Cambodia by the United Nations Environment Programme (UNEP) and the Ministry of Land Management, Urban Planning and Construction
- GGGI Strategy 2030, including country frameworks and business plans for most AMS
- Asia Pacific Primer on Embodied Carbon (World Green Building Council Asia Pacific) that describes what embodied carbon is and where it occurs throughout the building and infrastructure asset life cycle
- ACE's Zero Energy Building category as part of the annual ASEAN Energy Awards
- UNEP- United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP) SDG7 Localization, Affordable and Clean Energy in ASEAN cities (2021) report
- Asia-Pacific Economic Cooperation (APEC) Low Carbon Model Town (LCMT) project
- ACE 6th ASEAN Energy Outlook 2017-2040 (AEO6).

The Roadmap's implementation will result in multiple benefits

Improving energy efficiency and the decarbonisation of buildings offers a number of economic, social and environmental benefits beyond energy savings and emissions reductions that include: reducing air pollution, improving energy security, reducing the cost of energy and improving health outcomes (IEA, 2015). By accounting for multiple benefits, policy makers in ASEAN can integrate energy efficiency into a number of policy areas that are able to support multiple societal goals (Bragge, et al., 2021).

Multiple benefits of energy-efficient and low-carbon improvements in buildings



The increasing attention given to the multiple benefits of energy efficiency has led to a growing evidence base and to the development of methods needed to account for those benefits. Quantification of the monetary value of such benefits, where it is possible, can be used in decision-making during policy development and consumer choices. Policy frameworks capable of achieving different economic, social and environmental goals have been developed and are being tested. This has increased the confidence of policy makers to make a case for multiple benefits.

The potential benefits of buildings sector decarbonisation are discussed below.

Energy savings through improvements in building envelope and systems are among the most readily identified benefits of decarbonising the buildings stock. For the ASEAN region, compared to the Stated Policies Scenario, the IEA estimates that energy efficiency improvements to building envelopes and systems and behavioural changes together could reduce per capita energy intensity by 20% by 2030 from the 2019 levels (IEA, 2021a).

CO_2 emission reductions from buildings sector decarbonisation is the second most readily identified benefit. Through energy efficiency and demand reduction, emissions related to direct and indirect energy use in buildings will make a significant contribution to energy-related CO_2 emission reductions in ASEAN.

Fuel switching and improvements to building system performance that reduce fuel use can directly **reduce air pollution** ($PM_{2.5}$), which is one of the world's single largest environmental risks to human health. In ASEAN, around 80% of the population are exposed to levels of fine particulate matter that exceed the lowest World Health Organization interim target. This exposure was responsible for around 450 000 deaths in 2018. Long-term exposure to air pollutants increases the vulnerability of the population to respiratory infections and diseases (Kim, et al, 2018). Reducing the exposure to both indoor and outdoor air pollution will lead to better health and well-being. Within the Sustainable Development Scenario, the IEA estimated that air pollution-related deaths could fall to around 190 000 per year (IEA, 2019c).

Investment in energy efficiency can lead to **skilled job creation** through the retrofitting of existing buildings, more efficient new constructions and increasing access to clean fuels. Measures to improve the efficiency of buildings and appliances have been shown to generate 10 to15 job-years per million dollars invested (IEA, 2020b). Additionally, there is further opportunity to use investment in the energy efficiency of buildings to upskill workers, particularly through the adoption of standards that improve the stringency of buildings' energy and carbon performance.

In emerging and developing economies, energy efficiency has an important role to play in **increasing the affordability of energy**, which helps to increase energy use and has been shown to have positive economic benefits for households. Access to modern lighting alone has been shown to increase disposable income by USD 5-16 per month through productivity for poor households in developing countries (IRENA, 2012).

For populations with little or no access to modern energy, e.g. electricity, modern biofuels or low-carbon gas, the deploying of energy-efficient appliances can **reduce the costs of off-grid systems operations**, making energy services more affordable. Ability to pay is one of the largest barriers to expanding the uptake of off-grid technologies. Super-efficient products reduce the maximum load requirements on a system, which decrease capacity requirements for renewable

energy generation and result in an overall reduction in cost since investments in batteries and solar panels account for most of the energy access costs (IRENA, 2019).

Inefficient building fabrics and poor ventilation characteristics have **significant impacts on health**. In warm climates, exposure to heat is related to stroke and cardiorespiratory disease (Gasparrini et al., 2015), while heat waves in ASEAN have been shown to increase deaths during the hottest summer months and pose a significant risk to vulnerable populations (Campbell et al., 2018). By investing in improvements in building fabrics and energy systems, a more comfortable indoor environment can be achieved, such as more stable indoor temperatures or cleaner air (Maidment et al., 2014). Energy efficiency retrofits in buildings (for example insulation retrofits and weatherisation programmes) create conditions that can improve occupant health and well-being, particularly among vulnerable groups.

Energy efficiency can **enhance energy security** through reducing demand for supply from domestic production or imports, allowing for emergency energy reserves and excess capacity, and promoting fuel switching and/or demand restraint. Scaling up energy efficiency gains can help ASEAN reduce domestic energy demand, lowering demand for imports of oil, gas and coal. Currently, ASEAN's energy imports account for approximately 40% of total fuel demand. Improving building energy efficiency will help the AMS meet the increasing demand for energy and ease their reliance on fossil fuels (IEA, 2019c).

Further, building energy efficiency **improves resilience of supply** during periods of intensive weather or when capacity is constrained. Buildings that are more efficient will be more resilient to climate change. They will be better equipped to maintain comfort conditions during heatwaves and help reduce peak demand through more efficient cooling systems and appliances.

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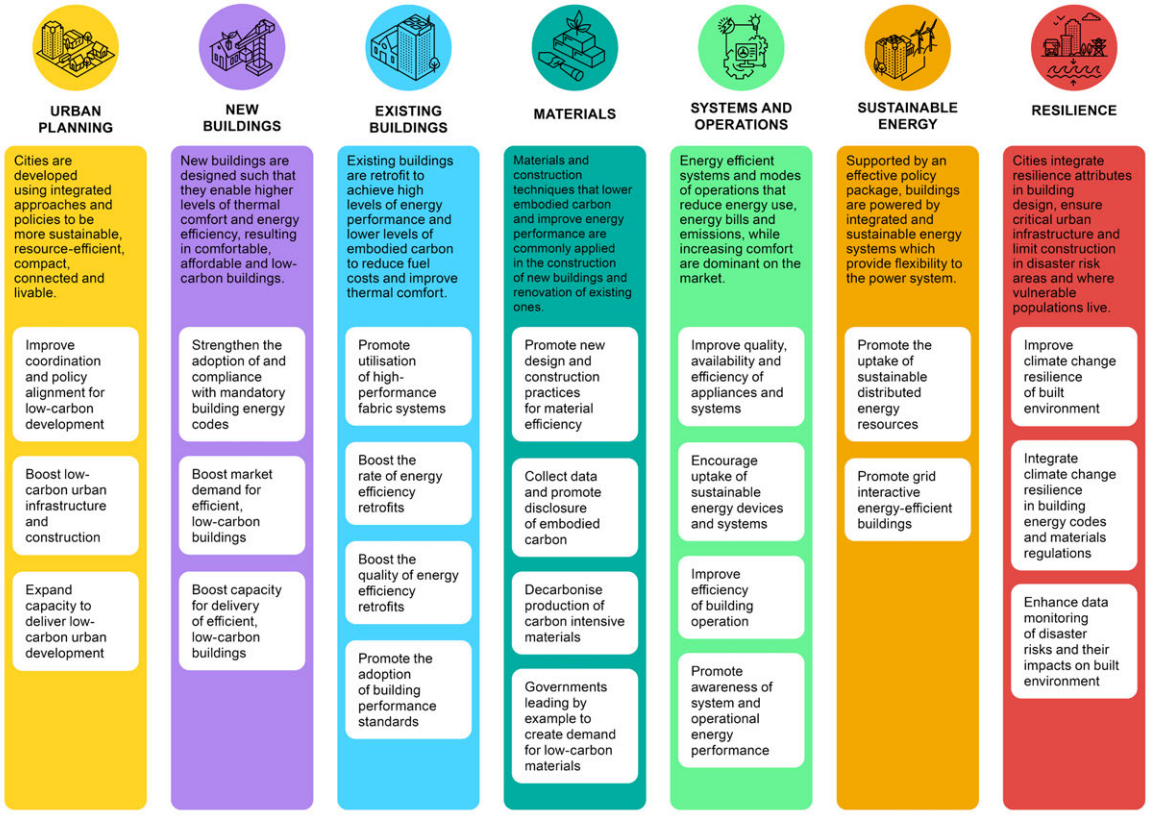
ASEAN Roadmap's action areas

This Roadmap is intended to identify common targets, milestones and timelines for key actions across seven "action areas" for the buildings and construction sector: urban planning, new buildings, existing buildings, materials, building systems and their operation, sustainable energy and resilience:

- **Action Area 1: Urban planning.** This area covers land use, zoning and other planning issues associated with how buildings, transport and energy systems interact.
- **Action Area 2: New buildings**. This area covers all aspects of the design and construction of new buildings, including the design process, design strategies and policies such as codes and labels.
- **Action Area 3: Existing buildings.** This area covers all aspects of the improvements of existing buildings.
- **Action Area 4: Materials.** This area covers building materials for the building envelope and structural materials used in buildings (it does not cover the materials used for manufacturing of appliances and equipment).
- **Action Area 5: Systems and operations.** This area covers all aspects of the operations and management of buildings including heating, cooling, hot water and lighting systems that are used in both new and existing buildings.
- **Action Area 6: Sustainable energy.** This area covers the transition to sustainable energy in buildings, including the generation of on-site renewable energy, district energy systems and the integration of variable renewables into the grid.
- **Action Area 7: Resilience.** This area covers the aspects of building resilience that enable increased capacity to adapt to and mitigate the effects of changing climate and natural disasters.

Each of the action areas provides a structure that includes a vision, as well as options for key actions and activities to support the transition to net zero-carbon buildings and construction.

Roadmap vision and actions for each action area



Each action area of the Roadmap has a similar structure.

Structure for each action area

Introduction
- Vision
- Guiding principles

Current context
- Trends and challenges
- Current policies

Summary of strategy
- Milestones to net zero carbon
- Summary of strategy elements
- Stakeholder mapping

Actions, Activities and Timelines
- Timelines
- Actions, Activities, Near-term recommendations
- Examples

Tracking progress
- Proposed regional and national indicators for tracking

Each activity area of the Roadmap can be read either in isolation or in conjunction with the other parts of the document. It is important to note, however, that this Roadmap outlines actions and timelines, which are important for a country to take in order to ensure that its buildings sector is on its way towards a net zero-carbon future. A holistic approach to its implementation is therefore crucial. This Roadmap offers the opportunity to set the net zero-carbon vision for national buildings sectors and start implementation from any area or action, with the understanding that the achievement of this requires a complex combination of various measures from all the activity areas.

This regional Roadmap acknowledges that every country has its unique context, with its challenges and priorities in the buildings sector and beyond. Consisting of ten member states, the ASEAN region has a great variety of national circumstances in the political, social, economic, environmental and social spheres. While the Roadmap offers a comprehensive menu of actions, each government can develop a suite of actions suitable to its local context and which is sufficiently ambitious to follow the pathway towards a net zero-carbon buildings sector within its country.

While working with this Roadmap it is important to keep in mind several overarching principles:

- **Adaptability.** This Roadmap is intended as guidance, not as a prescription. It outlines the important options across seven key areas. However, the AMS, with their discretion and in-depth knowledge of local context, can configure effective implementation plans with a unique configuration based on the suggested actions, and tailored to local circumstances, availability and quality of data, as well as financial and human resources.
- **Holistic approach.** The buildings sector is complex and fragmented, covering numerous technological systems, policy options, end uses, stakeholders and decision makers. When working with this Roadmap an integrated view on the buildings sector is important. While the short-term priorities could be set starting from any of the seven action areas discussed, for the long-term strategy to achieve net zero-carbon buildings it is important to cover all action areas in a holistic manner so as to avoid a lock-in effect of energy savings and GHG emissions reductions through a lack of ambition (Urge-Vorsatz, et.al, 2013).
- **Strategic planning.** The Roadmap provides an outline of potential actions that can be taken towards the achievement of the net zero-carbon goal for buildings. However, the actual realisation of this ambition depends on policy development and the implementation actions taken by each AMS in line with the Roadmap. Key for effective implementation are determining policy processes and strategic plans, in which those selected from the Roadmap's actions could be integrated, as well as the development of an implementation plan to define more granular actions to be implemented, identification of the institutions responsible for their implementation and the resources that can be allocated,

- **Multi-stakeholder collaboration**. Activities and actions outlined in this Roadmap require the engagement of various levels of governance and stakeholder groups. While framework building regulations and national policies are within the purview of national governments, the actual implementation of actions is usually executed at the subnational and local levels of governance. Therefore, it is crucial to establish effective communication channels between national, subnational and local governments, as well as coordination mechanisms based on the principles of multilevel governance (Coopenergy, 2015). It is also important to ensure that the interests of various stakeholder groups (private sectors, civil society, academia, general public, etc.) are taken into account during the work with this Roadmap and further implementation activities.

Action Area 1: Urban planning

Introduction

Sustainable urban planning frames the supply and demand for urban energy with a view to: 1) achieving economic and human development goals; 2) protecting the environment (including mitigating climate change, reducing air pollution and limiting resource depletion); and 3) improving the resilience of local communities and urban energy infrastructure to disasters (IEA, 2016; IPCC, 2018). As buildings are typically governed by rules set in urban planning regulations, it is important that their impact on energy consumption and their potential for local energy production are taken into consideration when defining urban planning and land-use policies, and deciding on development projects.

A key concept behind sustainable urban planning is to promote mixed use, adequately compact cities with appropriate density levels (Lohrey & Creutzig, 2016). They should also strive for polycentric urban growth, transit-oriented development,[9] sprawl containment, vibrant public spaces, naturalised and vegetated spaces and integrated infrastructure. To support the proliferation of net zero-carbon buildings, urban plans for new development must consider how urban form impacts energy demand through shape, size, density and configuration of the street network, green infrastructure and use of urban spaces. For existing developments, urban planning needs to promote redevelopment, infill development and regeneration that take into consideration energy systems and energy demand. At the building scale, compactness, height, orientation and mutual shading have a great influence on buildings' energy demand and local renewable energy potential. Urban planning policies can also plan and allow for large-scale deployment of renewables within the urban fabric.

Increased linkages between urban planning and its impact on energy use and emissions from buildings and transport through more integrated urban planning policies can play a significant role in embedding energy efficiency into spatial planning to support the transition towards zero-emission buildings and construction, as well as efficient and resilient urban form. The following vision sets out what cities across the AMS could achieve by embedding sustainable urban planning principles through the Roadmap.

[9] Transit-oriented development (TOD) is an urban planning and design strategy promoting urban development that is "compact, mixed-use, pedestrian- and bicycle-friendly", and closely integrated with mass transit by bringing together jobs, housing, services and amenities around public transport stations (Salat & Ollivier, 2017).

Vision for urban planning

Cities are context specific and developed using integrated approaches and policies to be more sustainable, resource-efficient, connected and liveable.

Current context

Urban development across ASEAN has increased over the last 15 years and the region now has more than 330 million people living in urban areas (estimated on the basis of UN ESCAP, 2021a and UN ESCAP, 2021b). This increased growth emphasises the need to develop with a focus on sustainability, resilience and innovation that promotes improvements in livelihoods for all citizens. The implication for cities in ASEAN is that there is a need to expand city infrastructure (e.g. energy, water, waste, transport) to all urban populations in the region while taking into consideration future energy requirements and reducing the embodied and operation emissions of those services.

Urban poverty is being tackled across the Southeast Asia. The share of urban population living under the poverty line has substantially decreased in the region, for example, in Indonesia from 19.4% in 1999 to 8.3% in 2014, in Thailand from 22.3% to 9% between 2000 and 2012 and from 35.2% to 12% in Viet Nam from 2002 to 2013 (OECD, 2016). Associated with the reduction in urban poverty is the shift in reducing the urban population living in slums, for example, between 2005 and 2018 Cambodia reduced it from 79% to 45%, Lao PDR from 80% to 21% and Viet Nam from 41% to 13%, though others have had an influx in informal developments (ADB, 2013). The COVID-19 pandemic has however exacerbated these conditions and a recent ASEAN report suggests more than 54 million people are at risk of being forced into poverty (ASEAN Secretariat, 2020).

The main cities of ASEAN have a range of urban planning policies that are focused on promoting low-energy and low-carbon buildings. However, to achieve the milestones set out in this Roadmap, there is a need to further leverage the important roles that cities play in promoting zero-carbon development.

Current status of policies for sustainable urban planning

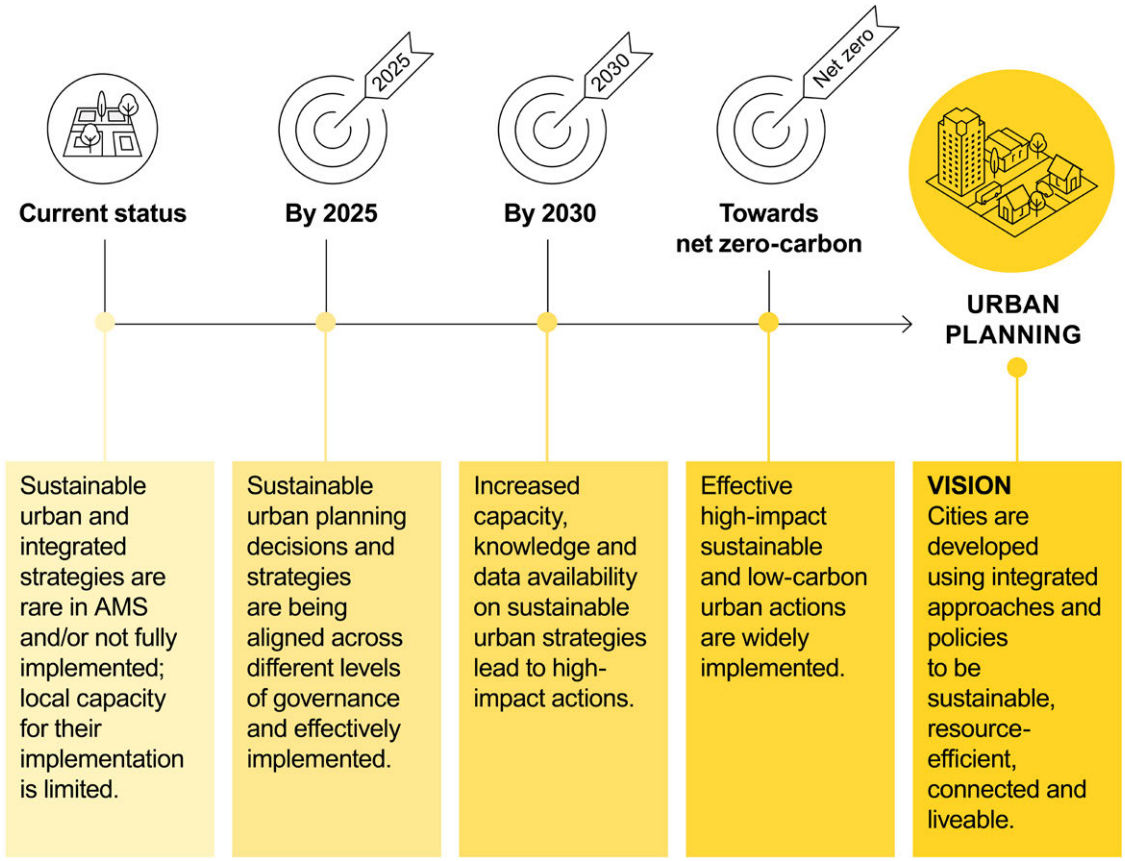
Country	Urban development controls	Sustainable urban masterplans	Development Incentives
Brunei Darussalam	Land use planning system and the Development Control System are in force. The NLUMP includes an Urban Footprint Zone to limit the extent of urban growth.	National Land Use Master Plan 2006-2025 (NLUMP), revised in 2008, proposes five national land use zones. There is also the Bandar Seri Begawan Development Plan.	National Housing Programme (RPN) is a policy which assists citizens in buying homes.

Country	Urban development controls	Sustainable urban masterplans	Development Incentives
Cambodia	2011 National Spatial Policy covers planning hierarchy. 2014 National Housing Policy covers access to housing. White Paper on Land Policy of 2015 sets out measures for managing and distributing lands.	Cambodia's Green City Strategic Planning Methodology (2016) is a step-by-step guide for Cambodia's cities regarding green growth. Phnom Penh Sustainable City Plan (2020) and Green City Strategic Plan 2016-2025 focus on the implementation of urban green growth, economic development, poverty alleviation and social inclusion.	
Indonesia	Law of the Republic of Indonesia N. 26 of 2007 concerning Spatial Planning covers sustainable measures for the development of zoning. Regulation of Ministry of Public Works and Housing 21/2021 regulates the administration of spatial development regulations, including the design and fixing of a guide comprising spatial development standards, processes and criteria.	Green City Action Plans (GCAPs) (2014-2017) provide investment plans and policy development, institutional restructuring, capacity development and training, technical studies and actions related to funding, financing and implementing projects.	
Lao PDR	Law on Urban Planning (1999) determines principles, regulations and measures regarding the management and use of land.	Vientiane Capital Master Plan (2020) considers sustainable urban planning.	
Malaysia	National Physical Plan (NPP) covers sustainable development and land use planning. .	National Low Carbon Cities Masterplan (NLCCM) in development. Low Carbon Cities Guide.	Melaka Green City Action Plan 2020: creation of incentive schemes, funding models, green procurement, PPPs. Green Development Incentives for Forest City (2016) include tax incentives for green developers. Sustainable City Awards. Low Carbon Cities Awards.

Country	Urban development controls	Sustainable urban masterplans	Development Incentives
Myanmar	Guidelines for Urban Planning (2020): covers sustainable urban planning.	Myanmar Sustainable Development Plan (2018-2030) and the National Transportation Master Plan (2011-2031) address sustainable national urbanism. Smart City Plans in Mandalay and Nay Pyi Taw	
Philippines	National Urban Development and Housing Framework (2017-2022) outlines the framework for urban planning.	Metropolitan Davao - Sustainable Urban Master Plan (in development) aims to guide the future growth and development of the metropolis.	
Singapore		Planning Act Master Plan Written Statement (2019) lists the territorial aspects and social, economic and environmental objectives of the government in order to guide sustainable and resilient development.	Built Environment Accelerate to Market Programme (BEAMP) (2020) and Skyrise Greenery Incentive Scheme 2.0 (SGIS) (2018)
Thailand	Spatial Planning System at the National and Regional Levels and Thailand National Spatial Development Plan 2057 address aspects of sustainability.	Climate Change Policy of the Kingdom of Thailand and Bangkok Metropolitan (2015), covers green urban planning and adaptation planning.	
Viet Nam	Plan for Green Growth Urban Development of Vietnam by 2030 [translated from Vietnamese] outlines priority areas that among others include application of information technology and green measures in the process of planning, design and construction of buildings and urban infrastructure		
ASEAN	ASEAN Sustainable Urbanisation Strategy (ASUS) (2018) employs a framework of sustainable urbanisation based on six areas, including quality environment and built infrastructure.	Master Plan on ASEAN Connectivity 2025 (2016) addresses five main themes: sustainable infrastructure, digital innovation, seamless logistics, regulatory excellence and people mobility.	

Note: Blank areas of the table indicate that no relevant information was found during data collection.

Summary of strategy for urban planningSummary of milestones for urban planning towards net zero-carbon

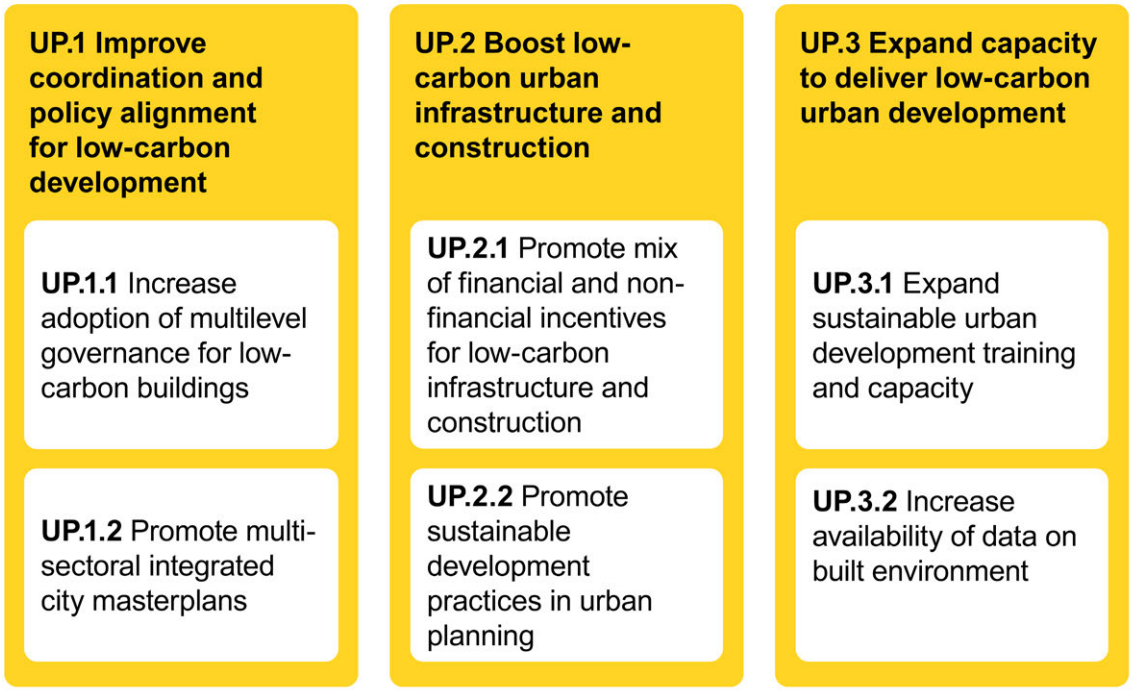


The Roadmap's strategy for how urban planning can advance energy efficiency and the decarbonisation of buildings in ASEAN includes three key actions in the area of urban planning (UP):

1. Improve co-ordination and policy alignment.
2. Boost low-carbon urban infrastructure and construction.
3. Expand capacity to deliver low-carbon urban development.

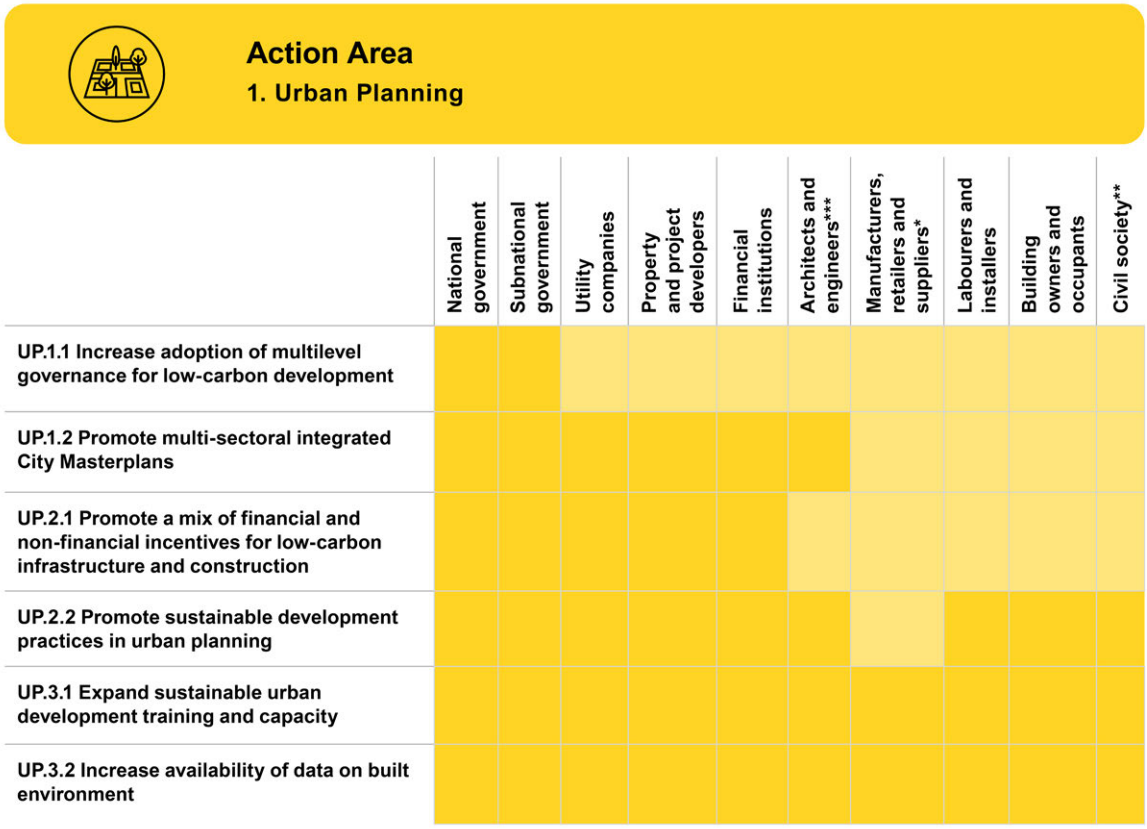
Within these actions, the Roadmap suggests six activities (e.g. UP.1.1, UP.2.2, etc.) related to urban planning.

Summary of Roadmap strategy for urban planning



As multi-stakeholder collaboration is one of the overarching principles of this Roadmap it is important to consider which stakeholder groups could be involved in the delivery of each activity. Various stakeholder groups should be involved in the activities under the Urban Planning action area in order to ensure their effective implementation.

Stakeholder mapping for urban planning



*of appliances and materials. Includes product testers and certifiers. ** including academia, non-governmental organisations (NGOs), research institutions, social networks and community associations. *** in the Urban Planning Action Area this stakeholder group also includes urban planners.

Note: The darker the colour, the higher the importance of that stakeholder group for the activity and the more essential the group is for the activity's effective implementation.

Actions, activities and timelines

UP.1: Improve co-ordination and policy alignment for low-carbon development

UP.1.1. Increase adoption of multilevel governance for low-carbon buildings	**Current status:** Effective multilevel governance (MLG) strategies are rare in AMS and/or not fully implemented.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	All member states develop MLG frameworks that cover the area of low-carbon buildings.	Co-ordination mechanisms under MLG frameworks are established in all AMS. Subnational and local governments are participating in the policy-making for low-carbon buildings.	MLG frameworks are effectively operating in all AMS. Subnational and local governments are implementing actions on low-carbon buildings aligned with national policies.

UP.1.2. Promote multi-sectoral integrated city masterplans	**Current status:** Minimal requirement for integration across sectors in masterplan development controls that can utilise synergies between sustainable energy, water, waste and transport, clean air, greenspace and natural landscape protection strategies.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	All AMS have introduced voluntary requirements for integrated multi sectoral masterplans development at the subnational and local levels.	All AMS have introduced mandatory requirements for integrated multisectoral masterplans development at the subnational and local levels.	All AMS have introduced requirements for integrated multisectoral masterplans development at the subnational and local levels aligned with national policies.

Near-term recommendations to support coordination and policy

Adoption of multilevel governance for low-carbon development

- **Development of the multilevel governance (MLG)** framework tailored to the needs and context of the country. "Multilevel governance" means co-ordinated actions that enable "working together across different levels of government, to deliver policies more effectively" (Coopenergy 2015). Such a framework could be integrated into the policy development processes based on the understanding of "the complex web of interactions between different levels of governments, non-state and non-governmental actors", all of which contribute to the actions taken to improve the energy efficiency of the country's buildings sectors (OECD, 2010). Such a framework is aimed at closing a policy gap between different levels of government by developing tools for vertical (e.g. national, regional and local governments) and horizontal (e.g. stakeholders within the same level of governance, e.g. within one city or co-operation with other cities) co-operation.
- **Vertical co-ordination**. National policy frameworks and effective co-ordinating mechanisms are important to ensure a stronger alignment between national and local policies towards sustainable urban planning. Subnational and local governments can be empowered by a sufficient level of autonomy to enable them to take actions under clearly defined national goals and commitments. Increased decentralisation of policy making and a wider range of "powers" (e.g. to develop policies, set targets, decide on the local energy mix, develop or modify local taxation, etc.) and responsibilities given to subnational and local governments could accelerate required implementation actions. National policy commitments and regulatory mechanisms could be supported by outreach and capacity building programmes for local policy makers to encourage a collaborative approach to sustainable urban planning and energy efficiency in buildings (OECD, 2016).
- **Horizontal collaboration**. National governments could support and encourage horizontal collaboration between various actors and stakeholders involved in urban planning at subnational and local levels. Decentralisation of governance

does not mean a withdrawal of national governments from local affairs, but rather active participation and continuous support.

- **Community engagement**. Development of stakeholder engagement initiatives at the local level can bring local citizens into the sustainable planning and development process and support local needs. It is especially important in order to ensure that local strategies are relevant and appropriate for the local needs and that they provide the basis for knowledge transfer to other communities.

Promotion of multisectoral integrated City Masterplans

- **Development of the City Masterplan.** Put in place the vision, policies and strategies to develop low-carbon development policies. Convene cross-division discussions and stakeholder consultations for development of the multisectoral official plan/city masterplan focused on developing amendments for adopting sustainable development policies and actions, including those that link low-carbon buildings with urban planning.
- **Integrated urban planning policies**. Enact urban planning policies that consider the long-term goal of decarbonising the buildings and construction sector. Urban planning policies would incrementally increase in scope to include not only the formal city but also informal settlements. Involve citizens and favour their active participation in the planning process to improve understanding of urban issues and foster the sharing of knowledge. Utilise potential and solutions offered by digitalisation that enable interlinkages between end uses (IEA, 2021a). For example, demand-side management, in combination with building energy management and interconnection to heat recovery facilities from industrial zones, data centres and waste-to-energy solutions, can empower stakeholders to set up large-scale programmes to achieve higher degrees of efficiency through sector coupling.
- **Business case for low-carbon development.** To leverage investment, produce business case studies to inform local governments and developers about the reduced operating expenditure benefits of low-carbon planning policies.
- **Showcase of data-driven development planning**. Data collection and analysis are foundational steps in the development of the integrated masterplan. Utilisation of digitalisation tools and real data (e.g. advanced spatial energy planning, including geographic information system [GIS], digital twin modelling, etc.) in this process enables mapping of local renewable energy potential. Such utilisation helps to identify sources of inefficiency in the buildings sector and opportunities for reducing building energy use and related carbon emissions. It can also evaluate the benefits and impacts of measures and policies beyond energy savings (IEA, 2021a).

Examples

- **The Asia-Pacific Economic Cooperation (APEC) Low-Carbon Model Town (LCMT)** aims to "combine energy-efficient buildings, transport and power systems to create communities that affordably reduce energy use and carbon emissions while creating pleasant living conditions". The LCMT project is a part of APEC's Energy Smart Communities Initiative and consists of two main activities: 1) development of the Concept of the Low-Carbon Town in the APEC region; and 2) 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 2021, the LCMT project conducted policy reviews of the following seven cities: Krasnoyarsk City, Russia; Mandaue, Cebu, Philippines; Bitung, North Sulawesi, Indonesia; San Borja, Lima, Peru; Da Nang, Viet Nam; Koh Samui, Thailand; and Yujiapu Central Business District, Tianjin, China.
- Smart city in Cambodia: This aims to create a smart city and an efficient and intelligent environment. Singapore-based Limestone Network began this development project in 2020. Covering 100 hectares in the centre of Cambodia's capital, Phnom Penh, the development is envisaged to be completed in 2022, with residential and non-residential buildings, malls, schools and a convention centre. A "'digital passport' for residents and workers will allow them full access to all the features of the Limestone app after thorough verification". They will be able "to make digital purchases and move from building to building within the smart city". The project adopts blockchain technology to enable efficient data collection via residents' daily touchpoints and its sharing without invading consumers' privacy. This allows for monitoring of a number of parameters to provide an "in-depth understanding of the city's functions, including road traffic, power and water consumption, resident movements and more", which is invaluable for urban planning and improving energy efficiency in various areas of the city's operations.

UP.2: Boost low-carbon urban infrastructure and construction

UP.2.1. Promote a mix of financial and non-financial incentives for low-carbon infrastructure and construction	**Current status:** Lack of financial and non-financial incentives for development of low-carbon or energy-efficient buildings.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Several AMS have included in their building policies a mix of financial and non-financial incentives for developers with enhanced sustainability provisions.	Most AMS have incorporated into national building policies a mix of financial and non-financial incentives for developers with enhanced sustainability provisions; they have also provided implementation guidance to subnational and local governments.	All AMS have an effectively functioning mix of financial and non-financial incentives for developers with enhanced sustainability provisions, implemented at the national, subnational, and local levels.

UP.2.2. Promote sustainable development practices in urban planning	**Current status:** Minimal planning for access to services, and for mixed-use and transit-oriented development (TOD).		
	By 2025:	By 2030:	Towards net zero-carbon
	Most new urban plans include TOD principles and voluntary mixed-use (e.g. residential, commercial) for large developments.	All urban plans include TOD principles and mandatory mixed-use planning for large developments.	Efficient urban space planning and TOD are fully integrated into all planning decisions.

Near-term recommendations to support low-carbon urban infrastructure and construction

- Promote a mix of financial and non-financial incentives for low-carbon infrastructure and construction
- **Non-financial incentives**. Co-ordinate city planning divisions to explore and adopt non-financial incentives for new development applications, including expedited development review and approval, fee reductions, density bonuses and development allowances. Non-financial incentives are typically used "to promote private sector participation and social acceptance of sustainable and energy-efficient construction projects" through, for example, reducing time for administrative procedures, simplifying construction processes and offering project bonuses as well as incentives, recognitions and market tools (PEEB, 2021).
- **Financial incentives:** Financial incentives can be offered such as grants, specific loan schemes, tax rebates, fee refunds and control caps put in place to encourage development that is in line with the aim of reaching zero-carbon, efficient and resilient buildings and cities.
- Promote sustainable development practices in urban planning and infrastructure
- **District energy planning.** Encourage local governments to apply 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 utilities for cooling and renewable electricity systems and increasing supply options in existing dense urban environments.
- **Transport and transit-oriented development**. Encourage local governments to implement TOD in their city's actions on compact urban form and mixed land use in combination with public transport infrastructure, safe active mobility infrastructure and increased walkability.
- **Smart technology deployment**. Encourage local governments to deploy smart city technologies to increase the collection of data. Incentivise development of smart energy grids in cities to ensure that energy systems are operating in an optimal way, with inefficiencies and faults quickly identified and addressed.

- **Enforcement of spatial plans.** Incorporate into the national building regulation a process for enforcement of spatial plans and construction site reviews that requires on-site inspections to ensure that the actual construction corresponds to the approved design features.

Examples

- **Singapore Land Transport Master Plan:** A leader in TOD, Singapore's Land Transport Master Plan includes targets for 80% of residents by 2030 to live within a 10-minute walking radius of a train station and for 75% of peak-hour trips to be made by public transport. An important dimension of Singapore's urban design principles is a strong focus on overall walkability through a dense pedestrian network, which includes covered walkways, through-block links and connections which link upper and basement levels. Importantly, Singapore's adoption of TOD includes the provision of affordable public housing in well-connected areas.
- **Iskandar Malaysia Bus Rapid Transit:** Iskandar in Johor State, Malaysia piloted the use of low-carbon electric bus fleets connected to the Rapid Transit System (Iskandar Rapid Transit), Senai International Airport, Larkin Sentral, Gemas-Johor Baru electrified double-tracking project and ferry services at Stulang Laut and Iskandar Puteri. Stations will be planned to incorporate solar power and will have dedicated lanes to reduce travel time, which has often been the stigma of public transportation.
- **New Clark City, Philippines:** The project to create New Clark City was approved in 2014 with a grand plan to transform a 9,450-hectare site into a planned metropolis with Garden City design principles. Divided into phases, all development is being managed and supervised by the Bases Conversion and Development Authority. The first phase is expected to be delivered in 2022. Most of the city will be a preserved area for public green spaces, making it one of the largest public parks in the Philippines, limiting 3,500 hectares of land to residential and commercial buildings as well as government offices.
- Khon Kaen Municipality, Thailand: This is being implemented under the APEC Low-Carbon Model Town (LCMT) Project Dissemination Phase 3. The district of 46km^2 has a population of 120 000. Among the initiatives are strategies for green space, energy saving and sustainable development, which resulted in some 30 000 tonnes of CO_2 reduction in 2018. Additional development planning includes an "energy management system with electric vehicles, buses, LRT (light rail transit), smart houses, clean energy sources such as solar, hydro, natural gas and near zero energy buildings" (APEC Energy Working Group, 2020).

UP.3: Expand capacity to deliver low-carbon urban development

UP.3.1. Expand sustainable urban development training and capacity	**Current status:** Current institutional capacity for low-carbon and sustainable urban development is limited among national, subnational and local governments.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Support creation and/or uptake of training programmes on sustainable urban planning for government officials in the relevant departments at the national, subnational and local levels.	Officials trained in sustainable urban planning are employed by the government at the national, subnational and local levels in all AMS. These officials are actively developing sustainable urban projects and accessing financing for their implementation.	All AMS have dedicated and highly qualified teams working on sustainable urban policies and projects at the national, subnational and local levels which incorporate related principles into all new development activities in support of the net zero-carbon goal.
UP.3.2. Increase availability of data on built environment	**Current status:** Limited data collection and monitoring of energy, water use, waste and environmental infrastructure. Limited utilisation of digital tools for data collection and monitoring of urban development and land use.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Establish national data collection framework on building stock and building energy use with the focus on utilisation of digital tools and performance metrics for development and monitoring of public environmental assets (energy, water use, waste, emissions). Develop guidance for implementation of the framework at the subnational and local levels.	Establish open access monitoring networks and benchmarks for data on building stock, energy, water use, waste, emissions, and environmental infrastructure.	Widespread use of digital tools to efficiently collect data on building stock, energy, water use, waste, emissions, and environmental infrastructure, with benchmarks for performance assessment at the national, subnational and local levels.

Near-term recommendations to support low-carbon development capacity building

Expansion of sustainable urban development training and capacity

- **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. Provide training on how to work in collaboration across stakeholder groups including governmental and non-governmental actors.

- **Training professionals across territorial scales and disciplines**: Build capacity and awareness among service providers, including urban planners and designers, as well as technology providers about the broader framework of United Nations Sustainable Development Goals (SDGs), 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.
- Increase availability of data on the built environment
- **Data management tools.** Support the increased use of relevant tools that allow the treatment of data and information, such as geographic information system (GIS) mapping, building information modelling, satellite images, cost data, benefits analysis and life cycle analysis to make information-based decisions in the urban planning process. Applications include among others: automated streetlights, building management systems, electric grid controls and sensors, and optimised traffic and transit solutions.
- **Guidance for other levels of governance.** Develop guidance and incentives for subnational and local governments on how to develop data collection systems and frameworks on building stock, energy, water use and environmental infrastructure. Provide recommendations on how these systems could be aligned with the national data requirements in order to establish benchmarks for performance assessment and ensure effective monitoring processes at the local levels that could be aggregated and consolidated into the national data management system.

Examples

- **Da Nang City Lab:** In 2010, the partnership between the city of Da Nang, Viet Nam and the United Nations Development Program (UNDP) began, with support ranging from public administration reform to the "Chatbot" initiative to provide citizens with real-time information such as flood feedback. In 2019, Da Nang set a target to become a green, resilient and smart city by 2045, based on the UNDP Accelerator Laboratories. Called the "City Lab", it aims to rethink the city's development for the 21st century.
- **Singapore's digital twin**: Virtual Singapore, is a "virtual 3D copy of the city state. It is a model that integrates GIS data with buildings information, modelling data to replicate the city's infrastructure, transport systems and buildings. In addition to providing static information like any other map, Virtual Singapore is updated with dynamic real-time data, on traffic and climate for example. The digital twin supports city stakeholders in their decision-making on diverse operations. Simulations of emergencies can be carried out to optimise evacuation routes. Given its dense population and built environment, Singapore can make use of the

tool to optimise the planning of new infrastructure – the authorities for the Yuhua area in Jurong East, Singapore are already exploiting the opportunity to investigate building a new bridge in a busy area of the city" (IEA, 2021a).

Tracking Progress

Indicators are an important tool for understanding the changes in conditions that affect whether progress towards a target of net zero-carbon buildings and construction is being made.

For urban planning, indicators that track the presence and changes in policies that drive development, along with those development activities and their features, are vital to understanding whether new and existing urban forms are contributing to the transition.

Potential indicators for tracking progress at a national scale may include:

- [UP.1.1] Presence of/Number of multilevel governance strategies covering zero/low-carbon development adopted by jurisdiction (e.g. city-state, city-state-national, state-national and city-national).
- [UP.1.2] Presence of/Number of multisectoral sustainable city masterplans or city sustainability strategies. May include integrated urban plans across transport, buildings, energy, water, waste, environment and climate resilience.
- [UP.2.1] Presence of/Type of non-financial incentives for low-carbon development construction.
- [UP.2.1] Presence of/Type of / Amount committed to financial incentives for low-carbon development construction.
- [UP.2.2] Presence of/Number of cities with plans supporting transit-oriented development.
- [UP.2.2] Proportion of population living in net zero neighbourhoods/ communities.
- [UP.3.1] Presence of/Number of training programmes and modules for government and city officials on sustainable and low-carbon urban development principles and practices.
- [UP.3.2] Presence of/Number of cities using data management tools for urban planning.

Action Area 2: New buildings

Introduction

This section addresses measures to reduce the operational energy, and consequently, operational carbon in new buildings, recognising that the design stage is where the greatest opportunities for savings lie. 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 4: Materials", and measures to increase the share and integration of renewable energy, as described in "Action Area 6: Sustainable Energy".

Strategies to reduce energy demand and improve thermal comfort in buildings in a hot climate include:

- optimising building form and orientation to limit heat gains
- reducing the area of glazing (or wall to window ratio) and optimising air flow through openings (such as windows)
- providing external and movable shading to reduce direct sunlight and heat gains
- selecting materials with high thermal resistance (i.e. providing insulation) for walls and roofs
- providing reflective surface finishes to walls and roofs.

Other strategies may be required depending on the specific climate (humidity, seasonal and diurnal temperature differences, etc.).

Some of these measures could be included in prescriptive or performance-based building codes, while integrated design[10] aims to address the multiple disciplines involved in building design to make the most of synergies between the architecture and active building systems. Integrated design also ensures that the design strategy is adapted to the specific building location and use (IEA, 2013).

The following vision sets out the long-term aspiration towards what could be achieved across ASEAN in the construction of new buildings.

Vision for New Buildings

New buildings are designed to be comfortable, affordable and low-carbon, resulting in higher levels of thermal comfort and energy efficiency.

[10] Integrated design is an interdisciplinary approach that focuses on bringing together multiple stakeholders in a collaborative design and development approach. It aims to find optimal solutions across stakeholders.

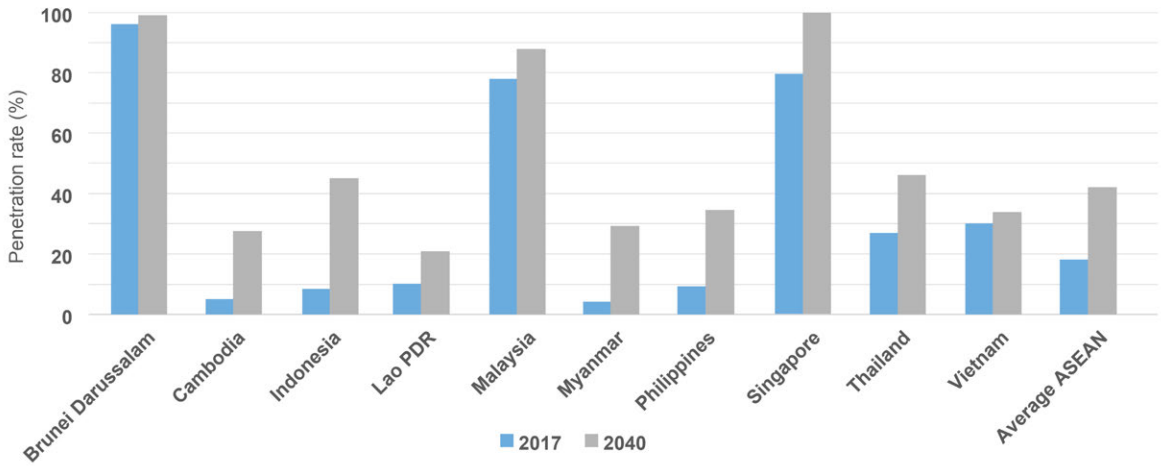
Current context

Asia will see a considerable rise in floor area, with an additional 65% of floor area to be built between 2020 and 2050, amounting to more than 70 billion m^2 within ASEAN, China and India (IEA, 2017). The majority of the growth will occur in the residential sector due to population growth and increasing income and the increase in appliance ownership and number of households (GlobalABC/IEA/UNEP, 2020).

While air conditioner ownership levels are still very low, high temperatures and humidity combined with rising incomes are driving an increase in space cooling demand, posing risks to the energy system, which is still particularly carbon intensive.

As shown in the figure below from the 6th ASEAN Energy Outlook, 2017-2040 (AEO6) (Ace & GIZ, 2020), while Brunei Darussalam, Malaysia and Singapore are expected to maintain high rates of AC ownership, a significant share of the ASEAN population is still expected to rely on passive and mixed solutions like fans for thermal comfort. Building efficiency therefore becomes a key pillar to reduce heat stress in this context, while contributing to reducing overall demand for cooling in air conditioned homes.

Potential evolution of penetration rates of air conditioners in ASEAN households



Source: 6th ASEAN Energy Outlook.

Overall, there remains a lack of mandatory building energy codes for all building types, new and existing, across the region. Only Singapore has a mandatory building energy code covering both the residential and non-residential sectors. Many other countries have voluntary codes, or mandatory codes for part of the sector, or only target very large building areas. Several other countries are still in

development phases of building codes and standards. However, regulating the construction industry in some jurisdictions may be limited and/or codes are poorly enforced.

The green building certification market is growing across the region, with several national and international green certification and rating programmes in use, many of which are linked to financial incentives. Further, in some jurisdictions while there may be federal laws to impose certain building design improvements, there are countries where the federal and state/province divide makes enforcement of building energy codes challenging.

There is progress being made towards a regional zero-carbon standard. For example, the new Zero Energy Building (ZEB) category has been recently added to the Energy-efficient Building category of the ASEAN Energy Awards, and provides a platform for refining the definitions for ZEB-ready, near-ZEB and Net-ZEB buildings. This categorisation could be used to form the basis of a regionally recognised standard.

Current status of policies for new buildings

Country	Energy codes	Labelling / Certification	Incentives
Brunei Darussalam	Ministry of Development PBD 12:2017, with input from the Public Works Department, Town and Country Planning Department, Ministry of Health, Fire and Rescue Department, Ministry of Home Affairs. EE&C Guidelines: the target to reduce energy intensity by 45% by 2035 with 2015 baseline through building guidelines for non-residential sector among other measures	Brunei Accredited Green Unified Seal certification, mandatory for government buildings. Extension to commercial buildings (under development).	
Cambodia	Ministry of Development with Cambodia Ministry of Energy and Industry launched the Construction Law in November 2019 which determines the guiding principles for the regulatory framework of the construction sector. The development of technical building regulations will follow in the coming years.[11]	CAMEEL certification: green certification for all types of buildings and all phases.	Energy Services Company (ESCO) Model (in development): to promote financial incentives for small and medium ESCOs.

[11] Energy Efficiency and Conservation Master Plan of Cambodia (Cambodia Ministry of Mines and Energy and Economic Research Institute for ASEAN and East Asia, 2020).

Country	Energy codes	Labelling / Certification	Incentives
Indonesia	Government Regulation No. 36/2005: mandatory for new buildings above 5 000 m² (commercial) and 500 m² (residential), but not strictly enforced. Government Regulation No.16/2021 on Buildings defines the function and classification of buildings, technical standards, building implementation, administrative sanctions, the role of community and capacity building. Government Regulation No. 21/2021 on the Assessment of Green Building Performance with mandatory energy efficiency for defined building types. National Energy Efficiency Standard for Buildings (updated 2020): covering energy conservation measures for building envelope, air conditioning system, lighting system and energy audit procedures for buildings (SNI 6389:2020). Local Building energy codes are mandatory in Jakarta, Bandung and Semarang, in development in Surabaya.	GREENSHIP certification: Rating system for buildings developed by the Green Building Council of Indonesia.	Indonesian Finance instrument (Green Bonds and Green sukuk): In force until 2023, the finance instrument covers the sectors of energy buildings, transport, water and water management, land use and adaptation.
Lao People's Democratic Republic	Proposals to develop policies for building codes covering fabric, heating/cooling systems and lighting and appliances (In development).		
Malaysia	Code of Practice Use of Energy Efficiency and Renewable Energy for Buildings: Voluntary for residential (MS2680) and non-residential (MS1525). Voluntary standards for residential, Mandatory for non-residential (for those > 4000 m²) [12]	National Building Energy Label (non-residential). Multiple certifications[13] (Voluntary) Several sustainable building certifications (Green Buildings/Sustainable Energy Low Carbon Buildings/Zero Energy Buildings).	

[12] MS 1525/2014 (Malaysia Department of Standards, 2014).
[13] PH JKR by PWD in 2012; GreenPASS by CIDB in 2012; MyCREST; Green Building Index (GBI), by private sector. Green Real Estate (GreenRE).

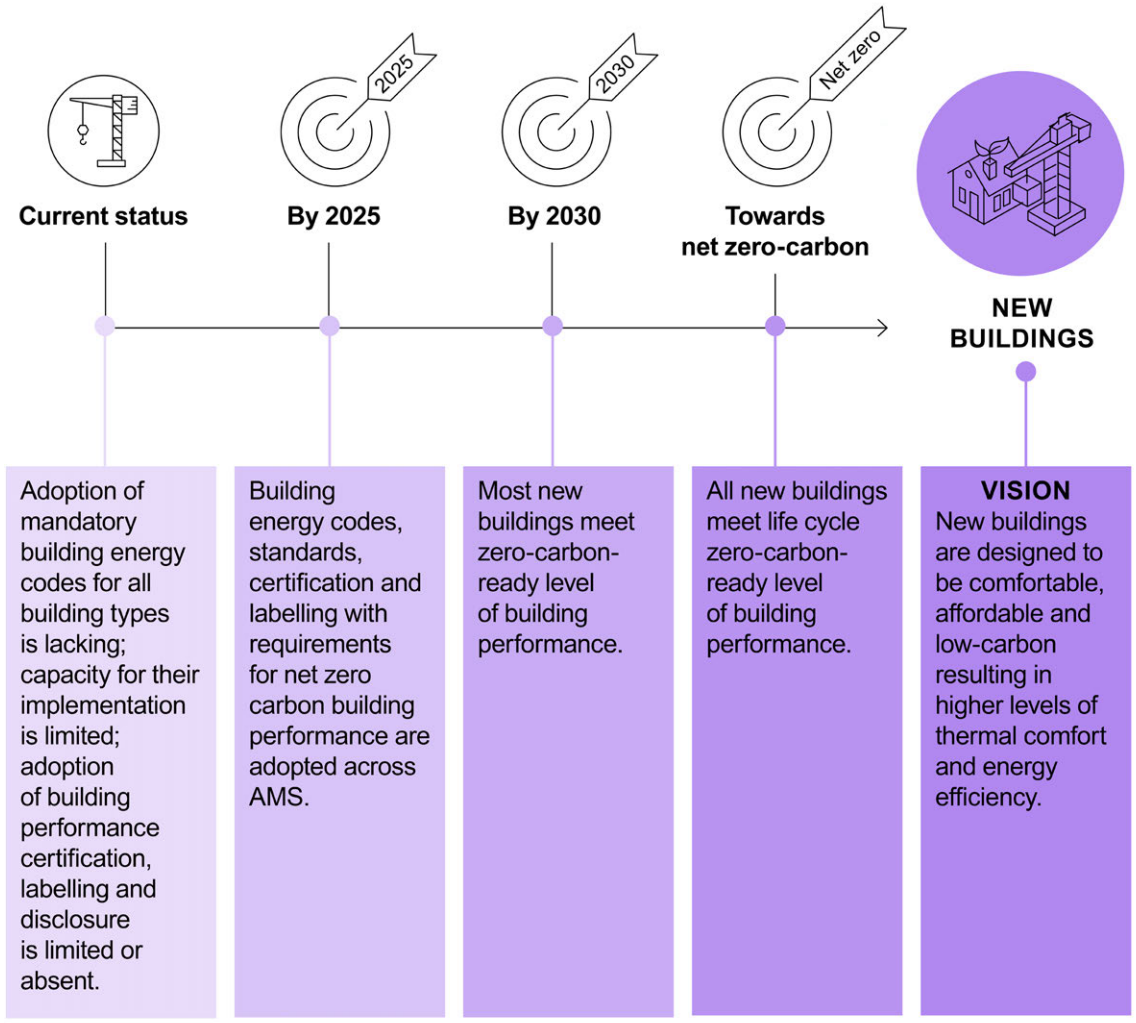
Country	Energy codes	Labelling / Certification	Incentives
Myanmar	In development, as a Green Building chapter in Myanmar National Building Code (MNBC).[14] Adopted on voluntary basis by one city (Yangon), EE&C Guidelines being developed by the Ministry of Information.		
Philippines	Philippines Green Building Code (mandatory): seeks to improve the efficiency of building performance through a framework of standards.[15]	Philippines Building for Ecologically Responsive Design Excellence Program (BERDE): green building rating system.	
Singapore	Code for Environmental Sustainability of Buildings 3rd Edition (2012) - Mandatory for all sectors.	Green Mark (GM): voluntary building rating tool.	Multiple incentives (capital funding, loan, technical assistance, credit guarantee, ESCOs and cash incentives).
Thailand	Building Energy Code (BEC) for new buildings; Mandatory for nine types of buildings with area larger than 2 000 m^2. Ministerial Regulation Prescribing Type or Size of Building and Standard, Criteria and Procedure in Designing Building for Energy Conservation B.E. 2563 (2020).	LEED (Leadership in Energy and Environmental Design), TREES (Thailand Rating of Energy and Environmental Sustainability), BEC Awards, Greening Thailand's Government Buildings, which include green building labelling scheme for government buildings.	Direct Subsidy Soft Loan (Energy Conservation Fund) Efficient buildings are eligible for higher floor area ratio (FAR) from Department of Public Works and Town & Country Planning.
Viet Nam	The Vietnam Energy Efficiency Building Code (QCVN 09: 2013/ BXD) developed as the national technical guide on energy efficiency for buildings. Energy Efficiency Building Code (EEBC) developed in 2013. Voluntary for large buildings (all sectors). Development for high rise, commercial and residential buildings ongoing.	The voluntary green rating tool LOTUS was formed by the Vietnam Green Building Council (VGBC) in 2010 based on various international green building rating systems. LOTUS aims to promote green building standards beyond energy efficiency that are specific to Vietnam. Other common standards include LEED, EDGE (Excellence in Design for Greater Efficiencies).	Incentives in development for science and technology research and development, and production and consumption of green/ eco- products.
ASEAN		ZEB category in the ASEAN Energy Awards	

Note: Blank areas of the table indicate that no relevant information was found during data collection.

[14] Myanmar building code development plan (UN ESCAP, 2017).
[15] Philippines Green Building Code (Philippines Department of Public Works and Highways, 2015) and (Philippines Department of Energy, 2020).

Summary of strategy for new buildings

Summary of milestones for new buildings towards net zero-carbon

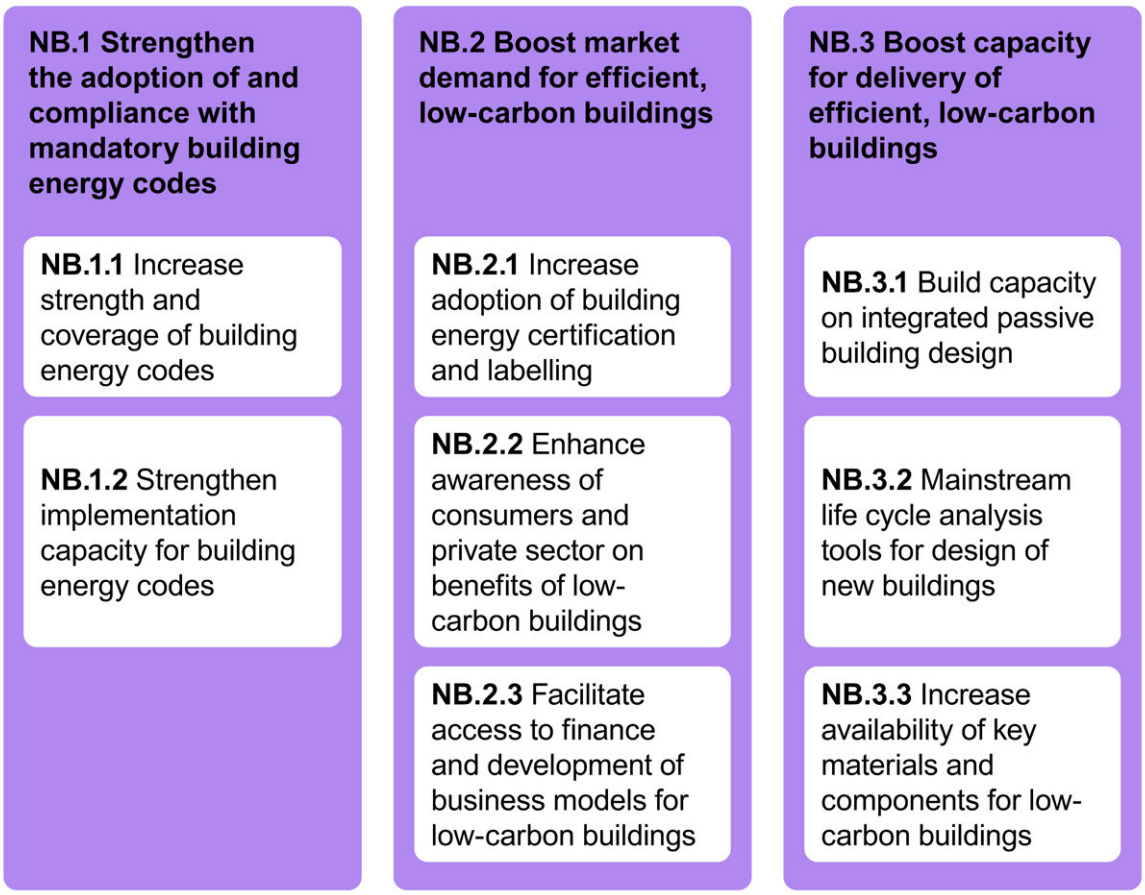


The figure below summarises the Roadmap's strategy for advancing energy efficiency and the decarbonisation of new buildings in ASEAN includes three key actions in the area of New Buildings (NB):

1. Strengthen the adoption of and compliance with mandatory building energy codes.
2. Boost market demand for efficient, low-carbon buildings.
3. Boost capacity for delivery of efficient, low-carbon buildings.

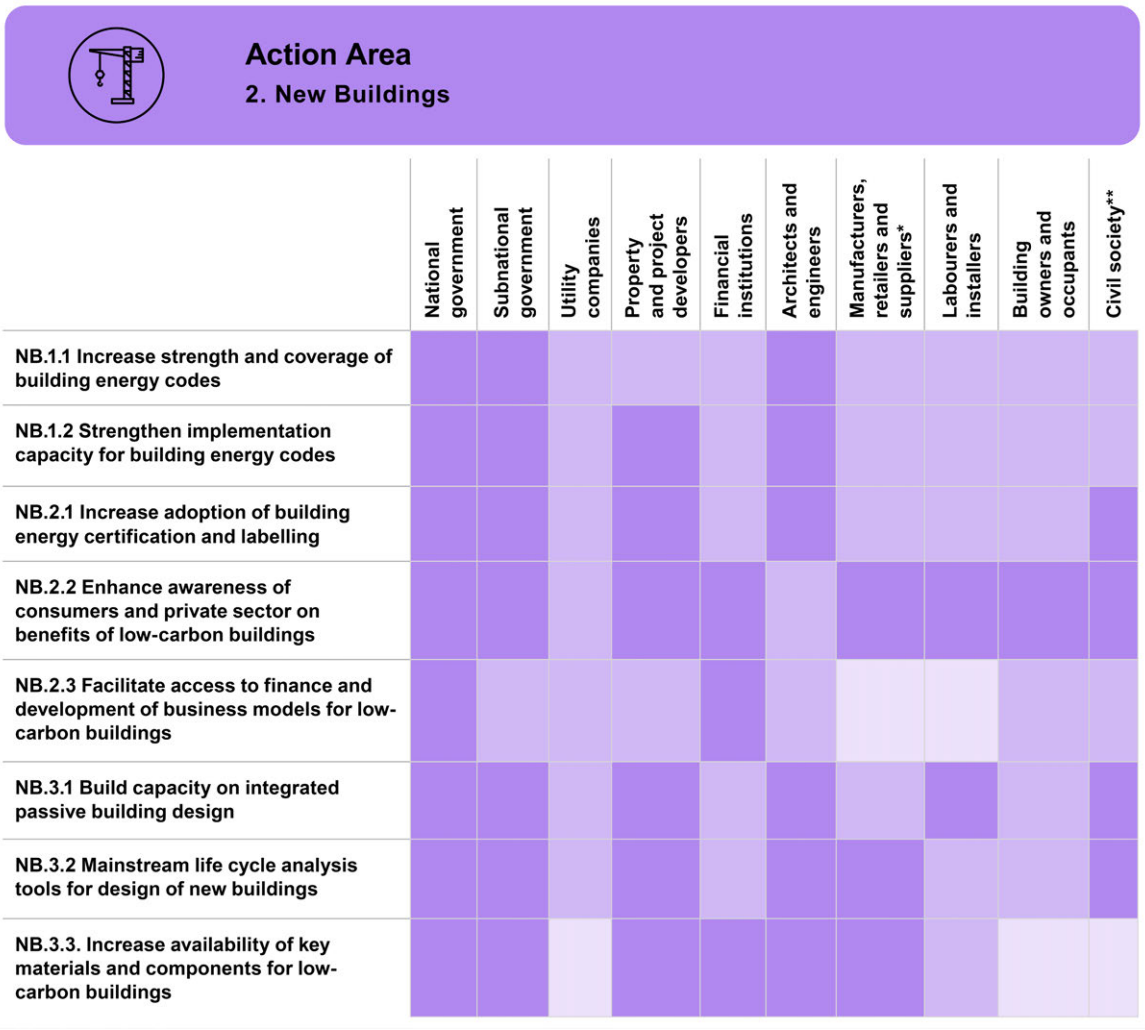
Within these Actions the Roadmap suggests eight Activities (e.g. NB.1.1, NB2.2, etc.) related to new buildings.

Summary of the Roadmap strategy for New Buildings



As multi-stakeholder collaboration is one of the overarching principles of this Roadmap, it is important to consider which stakeholder groups could be involved in the delivery of each activity. Various stakeholder groups should be involved in the activities under the New Buildings action area in order to ensure their effective implementation.

Stakeholder mapping for New Buildings



*of appliances and materials. Includes product testers and certifiers.

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

Note: The darker the colour, the higher the importance of that stakeholder group for the activity and the more essential the group is for the activity's effective implementation.

Actions, Activities and Timelines

NB.1: Strengthen the adoption of and compliance with mandatory building energy codes

NB.1.1 Increase strength and coverage of building energy codes	**Current status:** Across ASEAN, only Singapore has mandatory building energy codes (BECs) covering all sectors (residential, commercial and public). Some AMS have voluntary or mandatory codes for certain parts of the sector (often for buildings with the floor area above a certain threshold), and in others, building energy codes (BECs) are still under development.		
	By 2025:	**By 2030:**	**Towards net zero- carbon**
	All AMS have mandatory BECs covering all sectors. National governments provide guidance to subnational and local governments on implementation of BECs. Most AMS have national standards for net zero-carbon buildings.	All AMS include requirements for embodied carbon, urban planning, resilience and clean energy in their BECs, at least for new buildings. National governments provide guidance to subnational and local governments on implementation of BECs and these requirements. All AMS have standards for net zero-carbon buildings at the national and subnational levels.	All AMS, subnational and local jurisdictions have adopted net zero- carbon compatible BECs.
NB.1.2 Strengthen implementation capacity for building energy codes	**Current status:** Low implementation capacity for BECs at the national and local levels is a barrier to adoption and enforcement of mandatory BECs. Low adoption of voluntary standards across many AMS.		
	By 2025:	**By 2030:**	**Towards net zero- carbon**
	Tools developed to facilitate compliance checking and implementation of BECs at the subnational and local levels. Training programmes on BECs implementation and compliance are rolled out for national, subnational and local governmental officials. Most subnational jurisdictions adopt mandatory building code for public buildings.	Continuation of capacity building and accreditation programmes to support the roll-out of BECs. All subnational jurisdictions adopt mandatory BECs for public buildings. Most local/municipal jurisdictions implement local BECs in line with the national guidance and requirements.	Ongoing capacity building at all levels of governance and implementation chain. Full enforcement and compliance with BECs across all subnational and local jurisdictions.

Near-term recommendations to support the adoption of mandatory building energy codes

Increase strength and coverage of building energy codes

- Where existing BECs are voluntary, consider transition to mandatory ones.
- Integrate BECs and/or energy efficiency and conservation guidelines into national building technical regulations.
- Where BECs exist but apply only to large buildings, consider reducing the qualifying floor area threshold to increase the number of buildings to which the code applies.
- Where BECs exist, but only apply to certain types of buildings, consider expanding BEC's scope to include additional building types.
- Incorporate into BECs clear minimal energy efficiency and thermal performance standards that can be gradually strengthened with aspirations towards achieving net zero-carbon building performance during the period between 2030 and 2040, with regular revisions and increasing the ambition every 3-5 years.
- Set BECs or refer to guidelines for locally adapted bioclimatic design principles, and increasingly incorporate climate resilience and criteria for locally-sourced, bio-sourced and/or low embodied carbon materials.
- Develop a standard for defining net zero-carbon buildings, and gradually close the gap between mandatory policies and this standard. This process can build on the work undertaken in the new Zero Energy Building category of the ASEAN Energy Awards.
- Provide clear guidance on the implementation of BECs, as well as the enforcement strategy at the subnational and local levels, which could include compliance checking mechanisms, developing or strengthening digital platforms to facilitate compliance checking, monitoring and evaluation, as well as incentives (e.g. awards, recognition, etc.) for subnational and local governments, as well as developers, to go beyond the requirements of the national BECs.

Strengthen implementation capacity for building energy codes

- Provide training programmes for national, subnational and local governmental officials on implementation of BECs, including:
- How to collaborate across multiple stakeholder groups, including how to measure and 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 and databases.
- How to establish inter-ministry and multi stakeholder support to enable deployment of renewable energy to offset building energy use.

- Develop policies that ensure that all new government buildings are low-emission and efficient.
- Develop and implement demonstration or pilot projects on energy efficiency starting from public buildings to illustrate best practices and lead by example.

Examples

- **Singapore's super low energy (SLE) building programme**: Singapore's SLE programme was launched in 2018 and marks Singapore's push towards the next step in its green building journey (Singapore BCA, 2018). The SLE building programme intends to further improve energy efficiency in buildings, and to increase the use of on-site and offsite renewable energy and other intelligent energy management strategies. SLE buildings in Singapore achieve energy savings at least 60% above the 2005 building code levels. To meet this objective, the Singapore government has published an SLE technology roadmap and made the research and data from the Green Buildings Innovation Cluster available to the public through the SLEB Smart Hub. Given the land area constraints of Singapore, the deployment of renewables is a challenge. The emphasis is therefore on research and deployment of innovative cooling technologies to reach zero energy for buildings.
- **Cambodia's data collection exercise for policy design**: "In 2016, the Ministry of Industry, Mines and Energy of Cambodia published the first official energy statistics in Cambodia to contribute to the formulation of appropriate energy policies related to energy efficiency and building energy codes, as well as the green building rating tool of the Ministry. The energy statistics identify and explore areas for energy efficiency improvements" in buildings covered by benchmarking requirements, and aim to support the development of energy efficiency strategies in Cambodia. "The energy statistics also present and forecast the primary energy supply and final energy consumption by sector and the energy balance until the year 2035, among others. Prior to this, there were no official statistics in Cambodia; hence these statistics are important in estimating and monitoring energy consumption and planning for future energy use" (AGEP, 2018).
- Net Zero School Guidelines delivered to the Indonesian Government: GBC (Green Building Council) Indonesia, in collaboration with the Jakarta Provincial Government Education Office developed the Guidelines for Net Zero Energy Schools in January 2021 in connection with the Net Zero Pilot Project for the rebuilding of schools and government housing projects. The Guidelines consist of Basic Criteria and Prerequisites for the building of Net Zero Healthy Schools which can be used in the tender process for rebuilding schools (GBC Indonesia, 2021 [translated from Bahasa Indonesia]).
- GBC Indonesia Collaboration with GBPN for Buildings Sector Decarbonisation in Indonesia: Green Building Council Indonesia (GBC Indonesia) in collaboration with the Global Building Performance Network (GBPN) launched efforts to decarbonise the buildings sector in Indonesia. This collaboration will support GBC Indonesia's commitment to the World Green Building Council Roadmap and its

Net Zero- Carbon Buildings Commitment, which targets all new buildings in the world to operate at the net zero level by 2030, and all buildings in the world by 2050.

- **Prototype of low-carbon apartments in the hot-humid climates of Indonesia:** In 2016-2020, the Ministry of Public Works and Housing conducted research and development with the aim to establish the standard for energy-efficient apartment buildings. A prototype of an energy-efficient apartment building was constructed in the City of Tegal, Central Java. It incorporated both active and passive design considering local climatic conditions. It is expected that by using this hybrid technique, the energy consumption can be reduced by 40% per year. This project has been extended to 2026, targeting affordable apartments for low-income people. The current prototype of the apartments will rely fully on passive techniques and projections for thermal comfort requirements. Adaptive thermal comfort for tropical Indonesia in the face of a warming climate is being explored (Kataoka, et al. 2019). Life cycle energy and life cycle carbon assessments will be applied to identify the optimum design for low-carbon apartments. The results of the project will inform the development of a low-carbon apartment standard. It is also expected that newly constructed apartment buildings in Indonesia, both public and private, will use this standard as a guideline.
- Thailand's Strengthened Building Energy Code (BEC): The new Ministerial Regulation Prescribing Type or Size of Building and Standard, Criteria and Procedures in Designing Building for Energy Conservation, B.E. 2563 was adopted in 2020. The BEC requires that new or retrofit buildings with a floor area larger than 2 000m^2 must have their designs approved prior to construction or renovation. The BEC covers nine building types: hospitals, condominiums, hotels, academic institutes, exhibition buildings, entertainment services, offices, theatres and department stores. In accordance with the BEC, buildings under these criteria must be designed to meet the Ministerial Regulations standards specified to achieve energy conservation, including: 1. Building envelope properties such as overall thermal transfer value and roof thermal transfer value; 2. lighting system; 3. air conditioning system; 4. hot water generating system; 5. renewable energy utilisation; and 6. whole building performance.

NB.2: Boost market demand for efficient, low-carbon buildings

<table>
<tr><td rowspan="3">NB.2.1 Increase adoption of building energy certification and labelling</td><td colspan="3">Current status:
The green building certification market is growing, with 8 out of 10 AMS having implemented their own rating systems: Brunei (BAGUS), Cambodia (CAMEEL), Indonesia (Permen PUPR 21/2021, GREENSHIP), Malaysia (multiple), Philippines (GREEN), Singapore (Green Mark), Thailand (TEEAM) and Viet Nam (LOTUS). Not all certification schemes include requirements for energy efficiency.
In some cases, incentives are available and linked to these certification programmes.</td></tr>
<tr><td>By 2025:</td><td>By 2030:</td><td>Towards net zero- carbon</td></tr>
<tr><td>All AMS have implemented building rating and certification systems, aligned with requirements for net zero-carbon.
Incentives for achieving higher levels of building energy performance are available at the national, subnational and local levels.
Large and public buildings in all AMS require mandatory building energy efficiency labelling.</td><td>Share of certified and labelled buildings with high levels of energy performance according to adopted certification schemes reaches 25% of the buildings in ASEAN.
All certification schemes include targets and requirements to reduce embodied carbon from building construction.</td><td>Share of certified and labelled buildings with high levels of energy performance according to adopted certification schemes reaches at least 90% of the buildings in ASEAN.
All certification and rating systems in the AMS are aligned with net zero-carbon building requirements.</td></tr>
<tr><td rowspan="3">NB.2.2 Enhance awareness of consumers and private sector on the benefits of low-carbon buildings</td><td colspan="3">Current status:
Significant regional variation in awareness of benefits of low-energy and net zero-carbon buildings and available tools, although several excellent examples of low-carbon buildings exist.</td></tr>
<tr><td>By 2025:</td><td>By 2030:</td><td>Towards net zero- carbon</td></tr>
<tr><td>Increased general awareness of the benefits of low-carbon buildings, based on collected evidence from pilots.
Increased awareness of building designers and developers regarding cost-effective technologies and designs for net zero-carbon buildings.</td><td>Growing body of evidence on the multiple benefits of efficient and low-carbon buildings, at all levels of society and the economy.</td><td>Multiple benefits of efficient and low-carbon buildings are well-understood by various stakeholders in the AMS and are incorporated into the policy development processes.</td></tr>
</table>

NB.2.3. Facilitate access to finance and development of business models for low-carbon buildings	**Current status:** Regional variation in availability of dedicated financial products that provide favourable terms for energy-efficient buildings. Low level of awareness and adoption of financial and business models on energy efficiency in buildings.		
	By 2025:	**By 2030:**	**Towards net zero- carbon**
	Dedicated loans available in all AMS for the purchase of newly certified or labelled buildings, with increasingly favourable terms upon achievement of higher rating. Some AMS attempt to link building energy certification schemes to green mortgage and green bonds programmes and support lower interest rates for higher performing buildings.	Financial programmes for energy efficiency and low-carbon buildings are widely available and well-understood by developers and consumers in the AMS. All AMS have linked building energy certification schemes to green mortgage and green bonds programmes, and support lower interest rates for higher performing buildings.	Existing financial programmes are driving a wide uptake of energy-efficient and low-carbon buildings in the AMS.

Near-term recommendations to boost demand for energy-efficient buildings

Increase adoption of green and energy building certification and labelling

- Develop new and expand existing building certification schemes and support creation of localised rating tools on energy and carbon performance of buildings to be adopted in the ASEAN region, such as the ASEAN Energy Management Scheme (AEMAS) building gold certification and rating system.
- Require regular assessments (every 3-5 years) of building energy and carbon performance and related updates of building labels.
- Learning from existing third party certification schemes can be a good starting point to develop or expand national building energy certification schemes tailored to country context.
- Make disclosure of building energy and carbon performance information mandatory, especially at the point of sales or renovations.

Enhance awareness of consumers and private sector on benefits of net zero-carbon buildings

- 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.

- Offer training to developers, architects, designers and engineers, on energy-efficient and low-carbon solutions suitable for different building types in ASEAN.
- Where necessary, access international technical assistance to develop capacity building programmes for AMS, building upon international best practices in buildings.
- Develop building labels that have sufficient information to explain the energy and carbon performance of buildings, as well as the importance and benefits of low-carbon consumer choices when it comes to buying or renting building spaces.
- To enable consumers to make more low-carbon choices, introduce awareness raising programmes to inform them about the multiple benefits of efficient and low-carbon buildings. .
- Undertake pilot and award programmes for buildings of different types, collecting data on construction costs, construction times, CO_2 reductions, energy bill reduction, etc, to grow a body of evidence to support information campaigns targeted to different stakeholder types (including homeowners, manufacturers, developers, banks, local governments, national governments, etc).

Facilitate access to finance and development of business models for energy-efficient and net zero-carbon buildings

- The IFC's "Financial and Policy Blueprint for Green Buildings" estimates that "green buildings" provide a total investment opportunity of over USD 16 trillion in the East Asia Pacific, USD 7.6 of which is in the multi-unit residential sector, and USD 2.6 in commercial office space (IFC, 2019). In order to unlock this investment potential in energy efficiency and low-carbon buildings in ASEAN, access to finance must be improved and information regarding innovative financial mechanisms must be made accessible to a wide range of stakeholders, but especially to developers and consumers.
- Commercial banks could strive to develop and offer green financial products including green mortgages for buildings that can demonstrate high levels of energy and carbon performance. Such financing mechanisms could be linked to national and local building energy certification schemes, offering better financial terms such as lower interest rates and longer tenors, in relation to higher certification ratings. "In return, banks can expand their client base and product offerings, build higher-value and lower-risk portfolios, and access new sources of finance through green bonds, green securitisations and green credit facilities, potentially reducing their cost of capital" (IFC, 2019).
- Institutional investors and national and multinational development finance institutions also have key roles to play by supporting inter-coordination, risk guarantees and investment.
- Credit guarantees for green projects play a role in managing financial institution risks.

Examples

- Greenship Net Zero Building Rating Tools: GBC Indonesia has developed rating tools for buildings to be Net Zero Building Certified under a pilot project scheme. These rating tools have two levels 1) Net Zero Ready Building (renewable energy provides10% of building energy consumption) and 2) Net Zero Certified Building (renewable energy provides 100% of energy consumption).
- ZEB category of the ASEAN Energy Awards: These can form the basis of a regionally recognised ZEB standard and showcase leaders in the ASEAN region for Green Buildings. The EE&C Award is a "methodological support tool designed to provide public recognition for excellence in the field of energy efficiency and conservation. The award aims to enhance awareness and encouragement to private sector participation in EE&C, specifically in buildings and industry" (ACE, About ASEAN Energy Awards).
- Singapore's Green Mark rating tool: In an effort to encourage the early adoption of the Green Mark rating tool, Singapore had incentivised building developers with the allowance of a higher gross floor area as a means to offset the higher cost of green building. Existing private sector buildings participate in the Green Mark scheme on a voluntary basis, while the public sector is held to stricter mandatory requirements, under the GreenGov.SG initiatives. From 2021, all new and existing public buildings undergoing major retrofitting must attain Platinum Super Low Energy Standards. Green Mark 2021 provides a holistic certification scheme that drives high levels of energy efficiency with broader sustainability issues being tackled through the sustainability sections that cover Intelligence, Health and Well-being, Whole Life Carbon, Maintainability and Resilience, aligned to meet the United Nations Sustainable Development Goals SDGs), global ESG (environmental, social and governance) reporting frameworks and emerging sustainable finance taxonomies. The Whole life Carbon section looks at the project's carbon footprint, with a focus on embodied (or upfront) carbon, the use of sustainable construction or retrofit materials and methods, as well as the role of tenancies in the fitting out of their spaces. The section also evaluates building owners on their transition towards carbon neutrality at the asset level, translating the corporate objectives into tangible outcomes, as well as their support for tenancies to do the same.
- **Thailand BEC Award to increase awareness:** In 2010, the Department of Alternative Energy Development and Efficiency (DEDE) in Thailand's Ministry of Energy established the Coordinating Center of Energy Conservation Building Design (BEC Center) to provide information to any government sector, state enterprise or project stakeholder regarding the evaluation procedures of building plans for energy conservation as required by related ministerial regulations. The BEC Center creates collaborative networks between the government and private sectors in order to lay the foundation of energy conservation building design. BEC has been testing out the BEC labelling scheme for energy-efficient building design, with the labels awarded in three levels depending on the energy saving: 30-50% (Good), 50-70% (Very Good) and >70 % (Excellent).

NB.3 Boost capacity for delivery of energy-efficient, low-carbon buildings

NB.3.1. Build capacity in integrated passive building design	**Current status:** Increasing demand for space cooling because of high temperatures and humidity. Rapid urbanisation creates demand for high-rise buildings, typically with high embodied carbon. Integrated design through charrette processes and thermal simulation are not widespread, but are key to maximising passive design and reducing active space cooling loads.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Technical guidelines for optimisation of passive measures by building type are developed. Pool of particularly trained architects and engineers is created in all AMS. Support for wider utilisation of digital design tools is provided.	Digital tools like Building Information Modelling (BIM) and Building Energy Modelling (BEM) simulation mainstreamed in building design phase. Technical guidelines for optimisation of passive measures mainstreamed and regularly updated.	Integrated design process and passive measures are effectively utilised in all new building projects in accordance with technical guidelines.
NB.3.2 Mainstream life cycle analysis (LCA) tools for design of new buildings	**Current status:** Almost no LCA tools and methodologies are used in the design of new buildings. Some green building certifications require some form of life cycle analysis.		
	By 2025:	By 2030:	Towards net zero-carbon
	Methodologies adopted in all AMS for assessment of whole lifecycle energy and carbon, even if the assessment of embodied carbon is not quantitative. Requirements for carrying out LCA for new buildings are incorporated into all building energy certification systems.	LCA methodologies available and used in the design of most new buildings, and included as a requirement in building energy codes. LCA assessments based on increasingly robust and quantitative information.	Tools available to enable systematic comprehensive LCA, guiding optimal design decisions for whole lifecycle carbon.

NB.3.3. Increase availability of key materials and components for low-carbon buildings	**Current status:** Regional variability in availability of key materials; components for building high energy performance and low-carbon buildings, such as insulation, low thermal transmittance walling components and double or solar performance glazing are not widespread.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Insulation, low-e/SHGC (solar heat gain coefficient) glazing and double glazing are increasingly available on the market, cost-effective and adopted where appropriate.	High-performance materials and technologies are widely available on the market in the majority of AMS and the costs are decreasing.	High performance materials and technologies are widely available at affordable cost in all AMS.

Near-term recommendations to boost capacity for delivery of energy-efficient, low-carbon buildings

Build capacity for integrated passive building design

- 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, prioritising the optimisation of passive and mixed-mode solutions.
- Develop educational programmes at primary, secondary, vocational, university and adult education levels to increase knowledge about and develop skills in sustainable new buildings. Provide certification or accreditation for professionals in the sustainable construction sector. Increase the use of building design tools. The use of more integrated design processes and simulation or modelling tools such as building information modelling (BIM) which can support detailed building energy modelling (BEM) can help ensure higher performance in a cost-effective manner. The use of advanced design tools for whole building system design and operation is an ideal approach to support zero energy buildings For example the ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers) Energy Simulation-Aided Design Standard 209 (2018).

Mainstream life cycle analysis tools for the design of new buildings

- Develop and apply appropriate methods to assess the whole life cycle carbon of a building: if quantitative data are lacking initially, some estimates may be available for the most commonly used materials in the region. Account for the most carbon-intensive materials and the most common construction materials (cement, steel, aluminium, timber, PVC, etc.) with the best available first estimates that can be refined over time. Materials can be classified as high/medium/low embodied

carbon and by their carbon reduction potential (e.g. aluminium window frames vs PVC or timber), to enable simplified assessments to guide decisions.

Increase availability of key materials and components for low-carbon buildings

- Provide incentives (e.g. tax rebates and more favourable import procedures) to manufacturers and producers of low-carbon materials and components to supply more of such products to the market at competitive prices.

Examples

- EDGE **(Excellence in Design for Greater Efficiencies):** Free software that allows simple assessment of energy efficiency measures and materials compared to a local baseline. A building can be certified with EDGE if it achieves a 20% saving when compared to a baseline.
- Publication of technical guidelines: Active and passive technical design guideline development has been supported previously by multilateral organisations such as the United Nations Development Programme in ASEAN.
- Thailand Building Energy Code (BEC): In preparation for the implementation of the Building Energy Code, the Department of Alternative Energy Development and Efficiency (DEDE) is providing training courses which consist of: 1. BEC training for auditors, engineers, and architects: a total of 600 people (target of 2 000 people by end of 2022); 2. Training for building owners, energy consultants, and designers: a total of 3 500 people; 3. Training in the BEC permit approval process for local authorities: targeting 5 000 people by end 2022.
- **Thailand Training for Sustainable and Efficient Buildings:** This Division of Energy Human Resource Development, under DEDE, is responsible for educating and organising training courses on energy technology and efficient energy management for interested parties from both the private and public sectors. These courses include energy efficiency in cooling systems as part of programmes such as that for Personnel Responsible for Energy. The Division of Energy Human Resource Development is also in charge of the legal energy personnel certification. In addition, there are fee-based training courses on air conditioners arranged by the Air Conditioning Engineering Association of Thailand, Universities and relevant companies.

Tracking Progress

Indicators are an important tool for understanding the changes in conditions that affect whether progress towards a target of net zero-carbon buildings and construction is being made.

For new buildings, indicators that track the presence and changes in policies that set standards for building performance, such as building codes, bylaws and

minimum energy performance standards, design feature requirements and sustainable building certifications, are important elements to understanding whether new buildings are constructed more in the zero-carbon direction.

Potential indicators for tracking progress at a national scale may include:

- [NB.1.1] Presence of national and/or state level mandatory BECs with energy and carbon performance requirements for all building types/new and existing buildings.
- [NB.1.1] Number of issued building construction agreements/certificates under code requirements by building type.
- [NB.1.2] Number of building control officers per development application made and/or construction agreements issued by building size or number of units.
- [NB.1.2] Presence of bylaws that have integrated minimum performance energy standards for new buildings.
- [NB.2.1] Number of/Proportion of sustainable building energy certifications issued for all development applications or construction certificates issued and by level of certification achieved
- [NB.2.2] Level of awareness of requirements of building energy codes or certification, measured through a survey of construction professionals, and/or awareness and ranking of building codes/certifications through a survey of building purchasers
- [NB.2.3] Proportion of/Amount of green building finance committed [accessed/issued] per quarter/year for construction
- [NB.3.1] Number of accredited training courses and trained professionals with integrated passive building design certifications
- [NB.3.2] Presence of/Number of bylaws requiring LCA as part of standard building construction application, or enhanced /voluntary building construction application
- [NB.3.1] Presence of/Number of technical guidelines for supporting zero-carbon buildings
- [NB.3.1] Number of ZEB submissions to ASEAN Energy Awards.

Action Area 3: Existing buildings

Introduction

Improving the energy performance of existing buildings is an important way to reduce operational energy costs, improving the lifetime of the building systems through recommissioning, improving indoor environmental comfort conditions, reducing pollution from old building systems and reducing direct and indirect carbon emissions.

Renovation of the building envelope (walls, roof and windows) and service systems (e.g. cooling, heating and ventilation) is the first action to improve the energy performance of existing buildings, and should bring them to the standards for new buildings wherever possible. Existing building energy performance can be assessed in terms of their operational use compared with benchmarks and in terms of the efficiency of the appliances and systems they are equipped with.

The first action to addressing existing building performance is to address the recommissioning of existing systems that are within their operational lifetime (addressed in Activity 4: Systems and Operations). Following this, addressing heat flow across the building envelope by insulating against unwanted heat gains or losses on roofs, walls and glazing will ensure resilience against heat and cold events, and the maintenance of conditioned spaces. Solar control glazing and daylighting management form a major part of reducing heating and cooling energy demands. Alongside the fabric, ventilation must also be addressed to ensure adequate air supply and also provide an opportunity for passive heating and cooling. There is also an opportunity to consider structural, technical and sanitary infrastructure alongside energy efficiency retrofits. For ASEAN, a vision for existing buildings through energy efficiency renovation, retrofit and refurbishment of existing buildings represents an opportunity not only to upgrade the energy performance of a building but also to achieve multiple aims such as reduced fuel costs and thermal comfort.

Vision for Existing Buildings

Existing Buildings are renovated to achieve high levels of energy performance and lower levels of embodied carbon to reduce fuel costs and improve thermal comfort.

Current context

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

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 can be prioritised from a materials efficiency and life cycle perspective.

The challenges for existing buildings will be to adapt to changing climates, rising ownership of devices, growing demand for space cooling, increasing quality of the built environment, rapidly expanding cities and increasing risks of natural disasters, while reducing carbon emissions through improving their energy performance and efficiency. Both incentives and regulations will be imperative for enabling these transformations.

A key measure will be to seize the opportunity of building upgrades carried out for reasons other than energy performance to upgrade the buildings systems, envelopes and operations.

Current status of policies for existing buildings

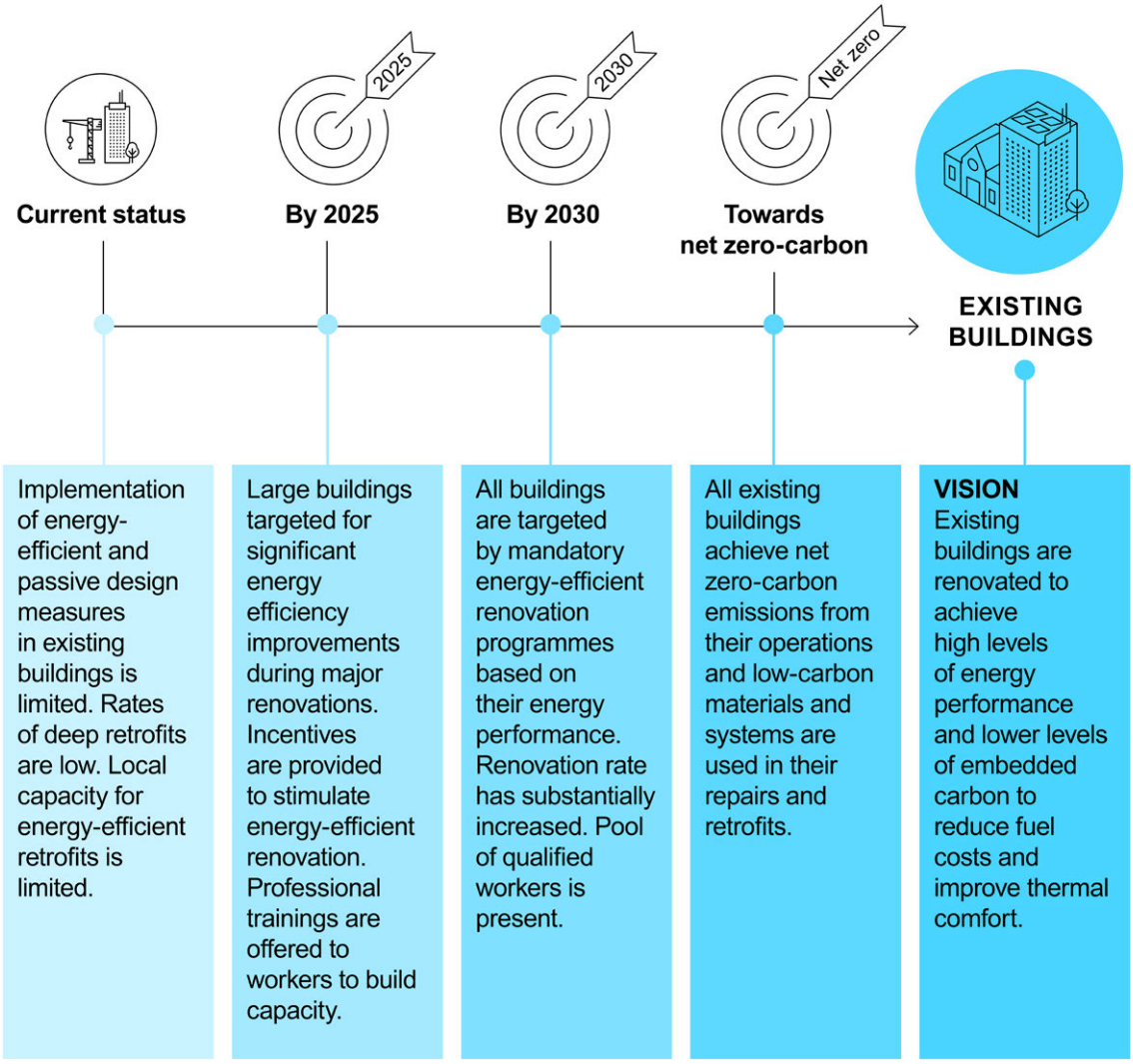
Country	Energy Benchmark Policies	Audits and Energy Renovation Policies	MEPS/codes
Brunei Darussalam			Building guidelines for non-residential sector: mandatory for government buildings and voluntary for commercial buildings.
Cambodia			
Indonesia	Benchmark tool developed for hospitality sector.	Voluntary standard for Audit procedure; Financial support available.	Mandatory minimum standards for commercial buildings
Lao PDR			
Malaysia		Energy Audit Conditional Grant (EACG) for large energy users.	Malaysia - MS1525: Code of Practice for Energy Efficiency and Use of Renewable Energy for new and existing Non-Residential Buildings.
Myanmar		Energy Efficiency and Conservation Policy, Strategy and Roadmap.	Myanmar Green Building - National Building Code

Country	Energy Benchmark Policies	Audits and Energy Renovation Policies	MEPS/codes
Philippines	The Philippines Energy Efficiency and Conservation Roadmap 2017-2040: promotes benchmarking and building ratings.	Energy Efficiency and Conservation Act (Republic Act No. 11285 of 2018): reveals new obligations regarding energy auditing.	Mandatory minimum standards for commercial buildings.
Singapore	Singapore BCA (Building and Construction Authority) Building Energy Benchmarking Reports.	Building Control Act - Periodic Energy Audits - covers requirements for energy audits on cooling systems in buildings Mandatory audits for new and existing building cooling systems. Financial incentives and financing support for retrofits.	Mandatory minimum standards for commercial buildings.
Thailand	Energy Efficiency Plan 2018 (EEP2018) targets reduction in energy intensity by 25% in 2030, based on the 2005 level. Plan to upgrade energy efficiency of common equipment/appliances used in buildings and homes.	Ministerial Regulation Prescribing Type or Size of Building and Standard, Criteria and Procedure in Designing Buildings for Energy Conservation B.E. 2563 (2020).	Building Energy Code (BEC) for large commercial buildings.
Viet Nam		Energy Audit Order: Large building owners included in energy audit obligation: any non-industrial (including residential, commercial, hospital and education) buildings with over 500 TOE or higher per year. Additional requirement to produce five-year efficiency plan.	Mandatory minimum standards for commercial buildings.
ASEAN			Mapping of Green Building Codes and Building Energy Efficiency in ASEAN: Towards guidelines for ASEAN Green Building Codes.

Note: Blank areas of the table indicate that no relevant information was found during data collection.

Summary of strategy for existing buildings

Summary of milestones for Existing Buildings towards net zero-carbon

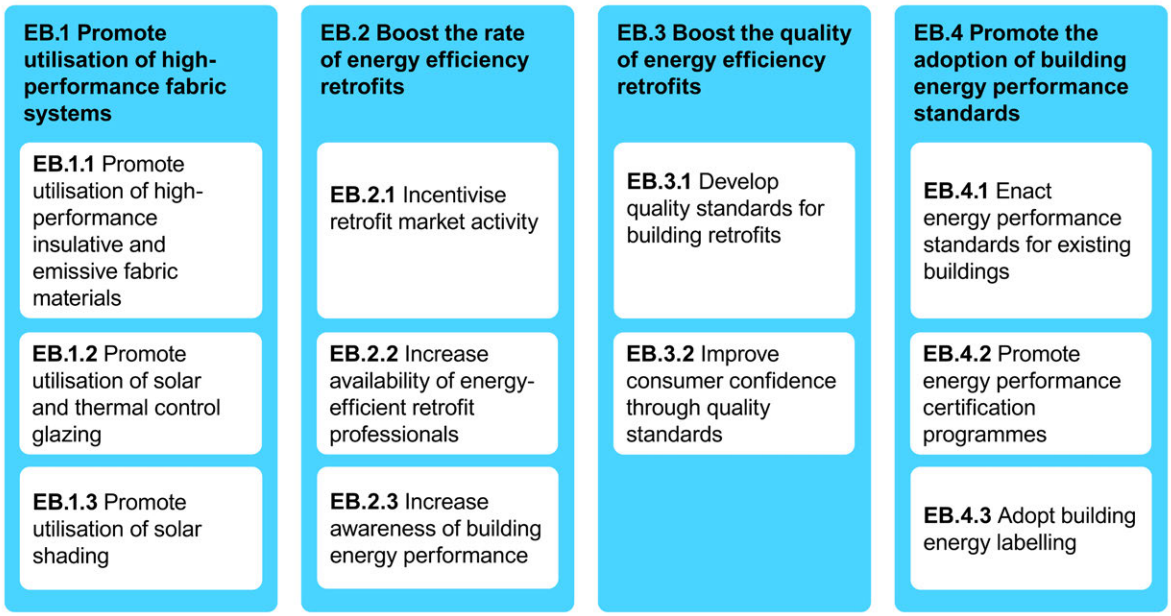


The Roadmap's strategy for advancing energy efficiency and the decarbonisation of existing buildings in ASEAN includes four key actions for Existing Buildings (EB):

1. Promote the uptake of high-performance fabric systems
2. Boost the rate of energy efficiency retrofits
3. Boost the quality of energy efficiency retrofits
4. Promote the adoption of performance standards and codes.

Within these Actions the Roadmap suggests eleven Activities (e.g. EB.1.1, EB.2.2, etc.) Those related to existing buildings are presented in the figure below.

Summary of Roadmap strategy for Existing Buildings



As multi-stakeholder collaboration is one of the overarching principles of this Roadmap, it is important to consider which stakeholder groups could be involved in the delivery of each activity. Various stakeholder groups should be involved in the activities under the Existing Buildings action area in order to ensure their effective implementation.

Stakeholder mapping for Existing Buildings

Action Area
3. Existing Buildings

	National government	Subnational government	Utility companies	Property and project developers	Financial institutions	Architects and engineers	Manufacturers, retailers and suppliers*	Labourers and installers	Building owners and occupants	Civil society**
EB.1.1 Promote utilisation of high-performance insulatve and emissive fabric materials										
EB.1.2 Promote utilisation of solar and thermal control glazing										
EB.1.3 Promote utilisation of solar shading										
EB.2.1 Incentivise retrofit market activity										
EB.2.2 Increase availability of energy efficiency retrofit professionals										
EB.2.3 Increase awareness of building energy performance										
EB.3.1 Develop quality standards for building retrofits										
EB.3.2 Improve consumer confidence through quality standards										
EB.4.1 Enact energy performance standards for existing buildings										
EB.4.2 Promote energy performance certification programmes										
EB.4.3 Adopt building energy labelling										

*of appliances and materials. Includes product testers and certifiers.

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

Note: The darker the colour, the higher the importance of that stakeholder group for the activity and the more essential the group is for the activity's effective implementation.

Actions, Activities and Timelines

EB.1: Promote utilisation of high-performance fabric systems

EB.1.1. Promote utilisation of high-performance insulative and emissive fabric materials	**Current status:** Insulation is not widely applied in roofs or walls (where appropriate) across the region and there is limited use of high-emissivity materials or coatings on roofs and walls.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Promote insulation of roofs in high occupancy buildings and where economically feasible. Insulate roofs and walls in buildings undertaking major refurbishment.	Insulate roofs and walls in all buildings undertaking major refurbishment with the use of high-emissivity materials or coatings.	Insulation of roofs and walls with the use of high-emissivity materials or coatings is applied in all existing buildings through redevelopment controls and targeted refurbishment actions.
EB.1.2. Promote utilisation of solar and thermal control glazing	**Current status:** Simple, unprotected and single glazing is common across most building types. Some countries have wide adoption of double glazing and solar control glazing in high-end commercial buildings.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Use of solar control films and emissivity coatings during major refurbishments is increasing for both residential and non-residential buildings.	Low-e coatings and solar control double glazing are widely applied in residential and non-residential buildings during major refurbishment.	Low-e coatings and solar control double glazing are applied in all existing buildings through redevelopment controls and targeted refurbishment actions.
EB 1.3. Promote utilisation of solar shading	**Current status:** Use of external shading is not widespread in most existing buildings; some external shading in traditional and historic designed buildings. Solar shading market is primarily focused on internal shades.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	External shading use promoted for retrofits and shading applied to all major refurbishments in residential and non-residential sector.	External shading in all retrofits in both residential and non-residential buildings. Adoption of solar reflective internal shading started.	Widespread use of static and movable external shading alongside internal solar reflective shading materials.

Near-term recommendations to promote high-performance fabric systems

Promote utilisation of insulative and emissive fabric materials, solar and thermal control glazing and solar shading

- **Develop and adopt policies and regulations.** Improving the insulation, solar glazing and control, and solar shading for existing buildings requires development of policies to raise performance standards, initiate the phase out of less efficient products and mandate minimum energy performance standards for refurbishment. Inspection controls can be applied to large refurbishments initially and then phased into the remainder of the market.
- **Develop a decarbonisation strategy for existing building stock.** Develop national green building ratings with requirements for energy efficiency and strategies that focus on the refurbishing and retrofitting of existing buildings towards low-carbon building performance. Strategies may consider residential and non-residential typologies and outline requirements for building fabric and glazing systems, as well as overall energy efficiency targets.
- **Introduce MEPS for existing public housing and public buildings.** The use of higher performance fabric, efficient mechanical and electrical equipment and glazing systems should be required for the refurbishment of all public housing and public buildings (schools, hospitals and government offices) to help develop the market. Likewise, energy performance contracts in public buildings could be offered for the same end.

EB.2: Boost the rate of energy efficiency retrofits

EB.2.1. Incentivise retrofit market activity	**Current status:** Low rate of energy retrofit of existing buildings to improve building energy performance. The market for energy performance retrofits is focused on high-end commercial buildings such as offices and hotels.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Incentives to accelerate and scale up retrofit activities through government stimulus for energy-efficient products; services and business models are adopted in regulation. Benchmark targets for large non-residential and residential buildings are set.	Mandatory minimum benchmark targets for large (e.g.>10 000 m^2m^2) non-residential and residential buildings are set. Energy performance benchmarks are developed for all building types. Highly efficient low-carbon refurbishment receives governmental support.	Minimum benchmark targets for energy performance are made mandatory for all buildings. Highly efficient low-carbon refurbishment has become a competitive common practice on the market.

EB.2.2. Increase availability of energy-efficient retrofit professionals	**Current status:** Building and construction professionals with deep energy efficiency training are rare. More programmes and training are needed to improve the availability of energy efficiency retrofit experts and high-performance product installers.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Certified training programmes developed and include modules on high performance products. Higher education programmes with dedicated modules on energy-efficient construction and renovation practices are offered in all AMS.	Extended education and vocational training programmes on energy-efficient construction, renovation practices and low-carbon technologies for construction professionals, architects, engineers, designers, etc. Standards and certification bodies provide accredited energy efficiency skills as part of licensing requirements.	A large pool of well-trained construction professionals, architects, engineers, designers with respect to energy-efficient construction and renovation practices, as well as low-carbon technologies, is widely available in all AMS.
EB.2.3. Increase awareness of building energy performance	**Current status:** Knowledge and data availability on building energy performance are limited with only few stakeholders having the information on performance features and approaches to improving operational performance.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Surveying and data collection work is undertaken to evaluate stakeholders' understanding and recognition of energy efficiency in existing buildings. Based on the survey's results, information programmes and awareness raising campaigns targeting various stakeholder groups are developed.	Information programmes and awareness raising campaigns targeting various stakeholder groups on energy-efficient operation practices in residential and non-residential buildings are implemented. Disclosure programmes on building energy performance are introduced and aligned with building energy rating schemes.	Understanding and recognition of energy-efficient operation practices are well-established through awareness raising campaigns and information programmes. Disclosure programmes on building energy performance are widely implemented and aligned with building energy rating schemes.

Near-term recommendations to boost rate of energy-efficient retrofits

Incentivise retrofit market activity

- Increase renovation rates**.** Annual renovation rates in the region should ideally reach 1.5% by 2025 and 2% by 2040 (IEA, 2020a) A variety of measures, including

financial and non-financial incentives, mandatory standards, awareness and education programmes, and government leadership programmes can support this process. Such incentives could be aligned with the retrofit 'trigger points'- such as change of ownership, renovation and end of equipment lifetime.

- Use stimulus programmes to invest in energy-efficient retrofits. Use these programmes as a means to promote energy efficiency measures for existing buildings through low-interest loans and micro grants, value-added tax reductions and point of sale rebates.
- Promote building energy performance audits through subsidised programmes to encourage utilisation of performance ratings.
- Offer energy performance contracts for public buildings to invigorate the market.

Increase availability of energy efficiency-efficient retrofit professionals

- Develop and implement energy efficiency training programmes. Support industry to expand availability of energy efficiency training programmes to current and former construction workers to boost their skills and employability.
- Promote benchmarking schemes. Develop audit schemes to establish benchmarks for building performance in order to improve building owners' understanding of their relative performance.

Increase awareness of building energy performance

- Improve data availability on building performance levels and make these data available through energy use disclosure programmes.
- Develop information programmes and awareness raising campaigns on the benefits of energy-efficient renovation.

Examples

- Brunei Household Survey: Data collection through household surveys to understand current consumption patterns (Economic Research Institute for ASEAN and East Asia & Brunei National Energy Research Institute, 2020).
- Singapore Energy Performance Contracting Standard: An energy performance contract (EPC) can guarantee energy savings for an existing building without an initial financial outlay. "To help building owners overcome the initial financial barrier to retrofit their buildings", the Building and Construction Authority (BCA) developed a publicly available standard EPC template for building owners and EPC firms. This document aims to "assist in accelerating the retrofit process" through simplifying the legal and administrative process for both building owners and the EPC firms (Singapore BCA, 2015).
- **Indonesia Building End Use Survey:** This survey measured building energy consumption in residential buildings and 207 commercial buildings and developed building energy use benchmarking.

- **Thailand:** Financial Support for Building Retrofit. In 2019, DEDE set up a subsidy programme for retrofitted buildings for nine types of eligible buildings, subsidising the cost of improving the building envelope and the roof to pass the BEC. Within the subsidy programme specific improvements include:
- 20% for designated buildings and factories when replacing with efficient equipment and machinery
- 30% for designated buildings and factories when replacing with efficient equipment and machinery with approved innovative technologies
- 30% for non-designated buildings and factories, community enterprises, start-ups, or those in the agriculture sector
- Supports up to THB3 million (approximately USD 90 000) per applicant
- Payback period no longer than 7 years.

EB.3: Boost quality of energy efficiency retrofits

EB.3.1. Develop quality standards for building retrofits	**Current status:** Use of quality standards in product installation and renovation practices are highly limited and there are only few existing certification schemes for building renovation actions in ASEAN Member States.		
	By 2025:	**By 2030:**	**Towards net zero- carbon**
	Develop industry standard for quality mark criteria for application to fabric and building system retrofits. Consumer Code for Builders and Renovators is developed to set mandatory requirements that builders and renovators must meet.	Require quality mark for large renovation projects and for key product sectors, i.e. cooling and hot water. More than 50% of ASEAN Member States have enforced utilisation of Consumer Code for Builders and Renovators.	Quality mark schemes for retrofit installations of most buildings systems are widely applied in non-residential and residential buildings. All ASEAN Member States have enforced utilisation of Consumer Code for Builders and Renovators.
EB.3.2. Improve consumer confidence through quality standards	**Current status:** There is a lack of consumer confidence in retrofit actions and their understanding of quality standards.		
	By 2025:	**By 2030:**	**Towards net zero- carbon**
	Voluntary industry-led building quality mark and certification scheme for building renovation actions developed.	Mandatory requirement for the adoption of a quality mark in renovation actions for all large buildings in residential and non-residential sector established.	Widespread confidence in retrofit actions and quality standard schemes.

Near-term recommendations to improve the quality of energy-efficient retrofits

Develop quality standards for building retrofit

- Develop regional or national databases of green and energy-efficient products for building renovation (including fabric and building systems).
- Prepare Consumer Code for Builders and Renovators to set mandatory requirements for energy-efficient renovation.

Improve consumer confidence through quality standards

- Incentivise the use of energy-efficient products, materials and systems during building renovation. Develop suitable incentive schemes to encourage the purchase and use of certified green building materials and energy-efficient systems. Enable programme implementation costs to be subsidised through listing on a regulated directory.
- Establish energy efficiency technical training and research centres. Promulgate the establishment of centres on energy efficiency in buildings and invest in human and technical resources. Define and implement vocational training for energy-efficient renovation and promote the use of energy-efficient technologies, products and materials during buildings' refurbishment.

Examples

- Chula Smart City: In 2018, ASEAN launched the "Smart City Network" in which each member state has selected up to three pilot cities to structure and develop a "Smart City" concept. Chulalongkorn University in Thailand, recognised as a green campus, has strived to transform its campus and surroundings into more than just a green university. The university created the "Chula Smart City", where Big Data is collected and shared in order to manage the campus' energy, water consumption, transportation, climate and pollution. Chulalongkorn University embraced the notion of "Smart 5" in leading its campus to become energy-efficient, which includes: 1) *Smart energy*: assessment of electricity demand at each point on campus and implementation of solar panels on the roof of college buildings as an alternative energy source; 2) *Smart mobility*: city connectivity offering electric and hybrid motorised bus (CU POP Bus), EV bikes, vehicle sharing and EV Tuks; 3) *Intelligent Community*: co-working spaces, gyms and a public park were included in the Intelligent City of Chula, ensuring community diversity; 4) *Smart Security*: guarantee of physical security and online security for those who use resources, through the integration of technology and big data; 5) *Smart environment*: air, noise and rain detectors were implemented.
- Energy-efficient buildings in Brunei: In the Temburong District, government and commercial buildings have undergone energy efficiency audits and have been certified with Building Energy Label Certificates. The certification is part of the Ministry of Energy's initiative to encourage and accelerate energy efficiency

actions in the buildings sector. The programme also provides information on energy consumption data and measures to improve energy efficiency and occupants' comfort. Since 2020, 13 of the 24 government and commercial buildings involved have already met the minimum Energy Efficiency Index (EEI)[16] set by the Ministry.

EB.4: Promote the adoption of building energy performance standards

EB.4.1. Enact energy performance standards for existing buildings	**Current status:** ASEAN countries have a number of certifications but a limited number of building energy codes covering existing buildings.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Voluntary performance-based BECs or standards for energy-efficient renovation are introduced for most buildings sector jurisdictions. Some BECs or standards include voluntary near-zero requirements for existing buildings.	Mandatory performance-based BECs or standards are adopted for all existing buildings in all AMS. All AMS have adopted BECs or standards that include voluntary near-zero requirements for existing buildings.	All member states have adopted performance-based BECs or standards that include mandatory net zero-carbon requirements for all existing buildings.
EB.4.2. Promote energy performance certification programmes	**Current status:** Certification programmes are available for existing buildings in few AMS, but they are not widely adopted outside certain sectors and buildings. Certification schemes are typically limited to specific building types or sectors or systems.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Voluntary certification standards are adopted for all types of existing buildings in all AMS. Independent industry-led testing facilities are emerging for retrofit products' testing and compliance.	Mandatory certification requirements are adopted for major renovations in large existing residential and non-residential buildings in all member states. Voluntary requirements for net zero-carbon renovations are included in the certification for all existing buildings. Certification for retrofit products is more widely adopted.	Mandatory certification requirements are adopted for major renovations in all existing residential and non-residential buildings in all AMS. Mandatory requirements for net zero-carbon renovations are included in the certification for all existing buildings. All building retrofit products are certified according to the standards.

[16] Consideration is for buildings above 1 000 m², while the energy efficiency index (EEI) for government office buildings is 130 kWh/m² and for commercial buildings is 180 kWh/m².

EB.4.3. Adopt building energy labelling	**Current status:** Few labelling programmes exist in the AMS for existing buildings.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Voluntary labelling schemes developed for existing buildings.	Mandatory labelling schemes are adopted for 50% of existing buildings in all AMS.	Mandatory building labelling is adopted for all existing buildings in all AMS.

Near-term recommendations to support building performance standards

Enact energy performance standards for existing buildings

- Increase the depth of renovation. Enable deep energy renovations that reduce energy consumption in existing buildings by 30-50% or more. In Asia, the building stock that was constructed more than 25 years ago will begin to require more substantial maintenance and refurbishment, particularly in large urban centres across the region. The establishment of specific standards and codes for the refurbishing of existing building energy performance is needed.
- Adopt energy performance codes and standards for existing buildings. Implement standards that require improvements to the building's energy performance of the envelope or systems when undertaking significant works, whether they were part of an energy retrofit or not. It is important that building energy codes are developed with respect to particular segments (e.g. commercial, multifamily residential and single homes) to ensure that refurbishments are carried out to align the performance of existing buildings with their cost-effective potential.
- Strengthen compliance with codes and standards and define appropriate compliance check procedures.

Promote energy performance certification programmes

- Adopt certification standards for existing buildings with the requirements for minimal energy performance after the renovation.
- Establish independent industry-led testing facilities for retrofit products' testing and compliance.

Adopt building energy labelling

- **Building labelling:** Quantitative building energy labelling can be used to assess building envelope and system characteristics on a scale from less to more efficient.

Tracking Progress

Indicators are an important tool for understanding the changes in conditions that affect whether progress towards a target of net zero-carbon buildings and construction is being made.

For existing buildings, indicators that track the presence and changes in policies that seek to improve building performance, such as building codes and bylaws for existing buildings, minimum energy performance standards for systems, building performance labelling and performance benchmarks, are important elements for the understanding of whether existing buildings are are increasing the zero-carbon stock.

Potential indicators for tracking progress at a national scale may include:

- [EB.1.1] Presence of minimum requirements for insulation and emissive fabric materials in building energy codes
- [EB.1.2] Presence of minimum requirements for solar and thermal control glazing in building energy codes
- [EB.1.3] Presence of minimum requirements for solar shading in building energy codes
- [EB.2.1] Value of retrofit market activity by building type based on surveys of companies' annual turnover
- [EB.2.2] Number of trained and certified retrofit professionals
- [EB.2.3] Level of awareness of building energy codes and certification features measured through surveys among construction professionals
- [EB.2.3] Level of awareness and ranking of building energy codes and certifications measured through surveys of building buyers and tenants.
- [EB.3.1] Presence of quality standards for building retrofits
- [EB.3.2] Presence of/Adoption of a quality mark or certification scheme for retrofits
- [EB.4.1] Presence of bylaws that have integrated minimum energy performance standards for existing buildings
- [EB.4.1] Presence of national and/or state mandatory building energy codes for refurbishment of residential, commercial and public buildings
- [EB4.2] Presence of/Percentage of/Number of Green certified refurbished buildings
- [EB4.3] Proportion of/Number of total green certified refurbished buildings

Action Area 4: Materials

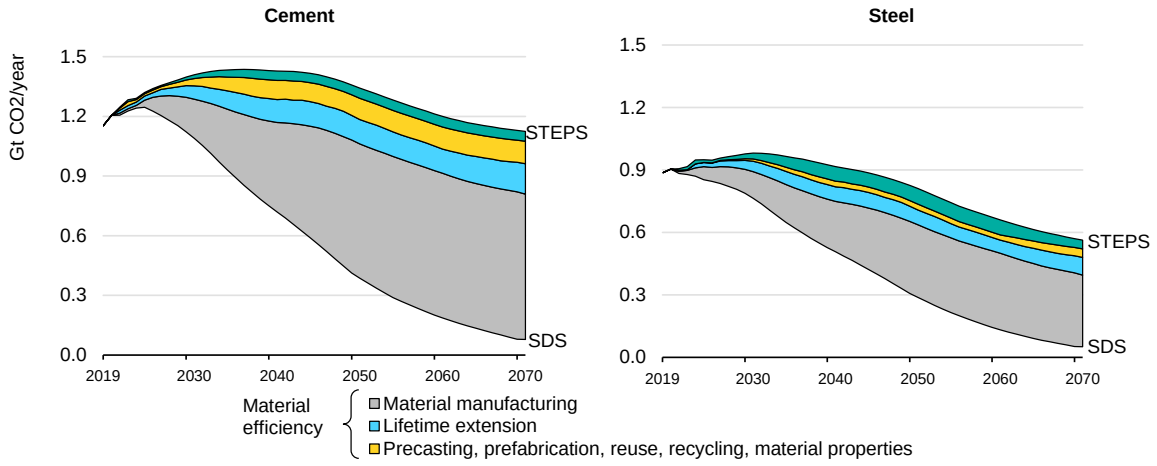
Introduction

This section discusses measures to reduce the embodied carbon of buildings, recognising that almost 11% of global emissions are caused by the extraction, manufacturing of building materials and construction of buildings (IEA, 2020b). This share is likely to increase in the future, given the continuous in floor area growth, 80% of which will be built in emerging economies and developing markets by 2050 (IEA, 2021b), and a high demand for high-rise buildings to accommodate growing urban populations.

GHG emissions and energy consumption are linked to every phase of the life cycle of materials, from extraction or harvesting to manufacturing, transportation, construction, use and demolition and disposal. Therefore, embodied carbon is the sum impact of all the carbon emissions attributed to the materials throughout their life cycle.

Reducing the embodied carbon from major building components such as cement and steel will be key to decarbonising construction (IEA, 2019a). 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 for materials, promoting switches to low-carbon and bio-based materials (i.e. the origin of the material is either plant-based or animal-based), to maximising energy efficiency in manufacturing and switching away from carbon-intensive sources of energy (ETC, 2018). There are also significant opportunities for expanding practices and systems that enable the reuse and recycling of construction materials.

CO_2 emissions related to steel and cement use in buildings by scenario, cumulative from 2019 to 2070



Notes: Emissions from materials lost insemi-manufacturing are not included. STEPS = Stated Policy Scenario, SDS = Sustainable Development Scenario.

Source: IEA (2020c).

Vision for Materials

Materials and construction techniques that lower embodied carbon and improve energy performance are commonly applied in the construction of new buildings and renovation of existing ones.

Current context

High rates of urbanisation are pushing demand for materials of high embodied carbon, such as iron, steel, cement and aluminium. Material efficiency including light weighting, extending buildings' lifetimes and using alternative materials and construction techniques could reduce the GHG emissions of residential buildings by 50-80% (IRP, 2020).

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

The need to shift towards affordable low-carbon and bio-based materials for use in buildings construction in the region is critical to achieving a whole-life net carbonisation of buildings. More widespread recognition of such materials will help promote their adoption, alongside shifts in the procurement process, and importantly, certification of low-carbon materials. Examples of green labelling of materials, databases and standards exist in the region, e.g. in Thailand and Viet Nam. However, data on embodied energy or embodied carbon per unit of the material is largely unavailable.

Further, the adoption of alternative construction methods can help improve the energy efficiency of construction and the reduction in material wastes, though it comes at a higher cost due to the demand for more skilled labour. Good examples of alternative construction methods exist, e.g. use of low-carbon concrete and mass engineered yimber in Singapore (DfMA in Singapore), which can reduce embodied carbon emissions while reducing construction times and waste, and increasing safety and reliability.

The World Green Building Council's Asia Pacific Embodied Carbon Primer (2020) established a comprehensive framework to reduce the embodied carbon emissions of construction in the region.

Current status of policies for low-carbon materials

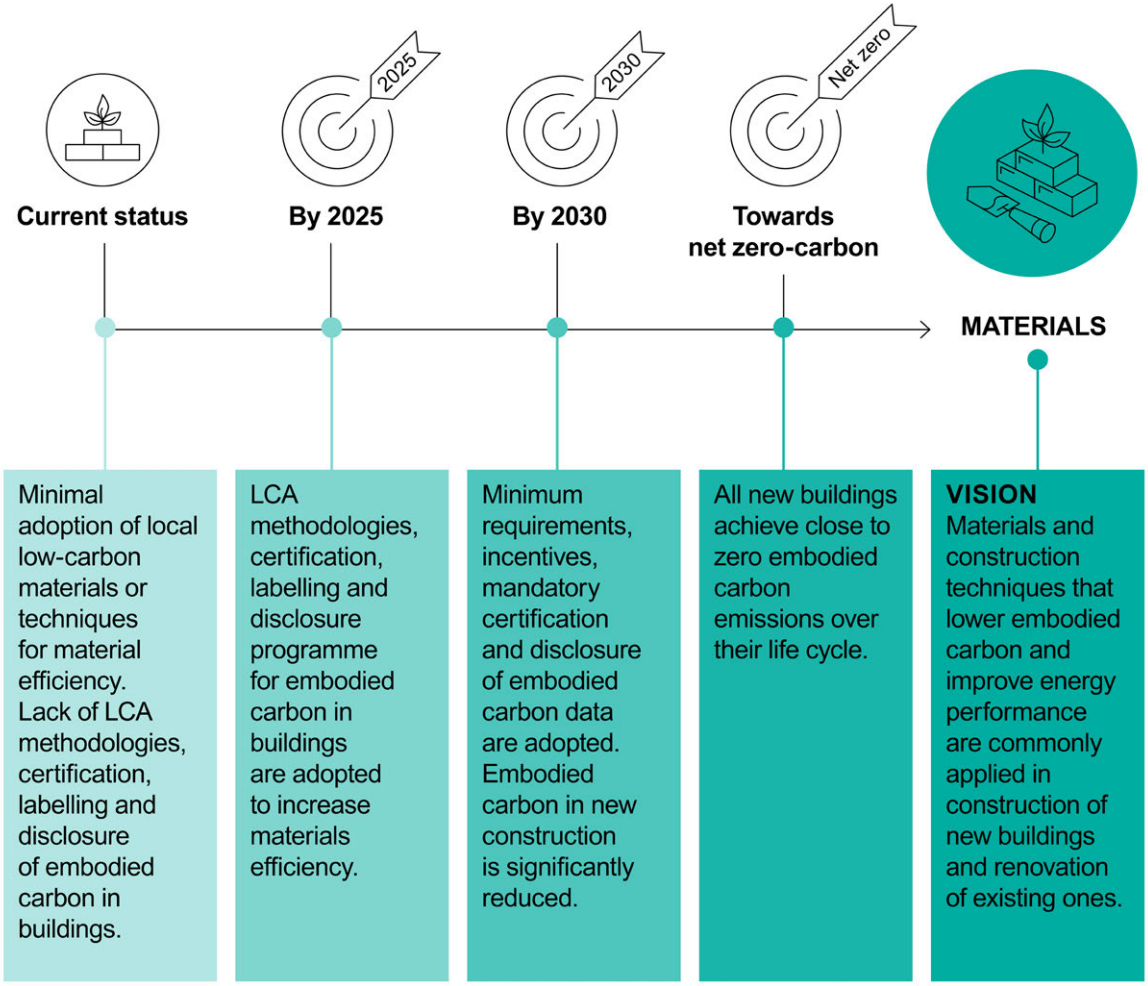
Country	Standards or labels for embodied carbon or energy	Lifecyle analysis (LCA) methodology	Green public procurement
Brunei Darussalam	Carbon emissions requirements: All facilities and agents that emit and absorb greenhouse gases are expected to submit their carbon data on a monthly and yearly basis.		
Cambodia	Green City Strategic Planning Methodology: New building permits to include standards for energy-efficient equipment and materials.		
Indonesia	Included in Regulation of Ministry of Public Works No. 21/2021: for new buildings, assessment parameters are the use of eco-labelling certified materials for construction; local concrete materials and manufacturers certified to ISO 14001.		Indonesian Roundtable on Greening the National Development Plan (2013) Includes projects that aim to encourage the production and consumption of sustainable materials.
Lao People's Democratic Republic			
Malaysia	Construction Industry Standard (CIS) 20: 2012 (both voluntary).	Malaysia life cycle inventory database.	Green Technology Masterplan 2017-2030 aims to strengthen green technology through Green Investment Tax Allowances on green technology equipment/assets and Green Income Tax Exemption for green technology service providers. The MyHIJAU Mark certifies and inventories green products.

Country	Standards or labels for embodied carbon or energy	Lifecyle analysis (LCA) methodology	Green public procurement
Myanmar			
Philippines		Included in GREEEN certification assessment. New Construction (BERDE-NC). BERDE (Building for Ecologically Responsive Design Excellence) is used to assess buildings.	
Singapore	Singapore Green Buildings Products, NEA Mandatory Energy Labelling Scheme.	Included in Green Mark 2021 under the Whole Life Carbon section.	Procurement requirements for a number of products used in the public sector under GreenGov.SG initiatives
Thailand	Included in Thai Rating of Energy and Environmental Sustainability (TREES). Including material re-use, recycling and locally produced materials with low pollution and environmental impact. High Energy Performance Standard (HEPS) and Labelling (Building Materials by DEDE). The Construction Carbon Reduction Certification is a voluntary initiative aimed at encouraging non-residential building owners to reduce greenhouse gas emissions by reducing electricity consumption, fossil fuel consumption and waste generation.		Green public procurement plan (Pollution Control Department).
Viet Nam		Vietnam Green Building Council (VGBC) established Inventory of Green Building materials	
ASEAN	MRA in development for Buildings and Construction Materials.	Asia Pacific Embodied Carbon Primer.	

Note: Blank areas of the table indicate that no relevant information was found during data collection.

Summary of strategy for materials

Summary of milestones for materials towards net zero-carbon

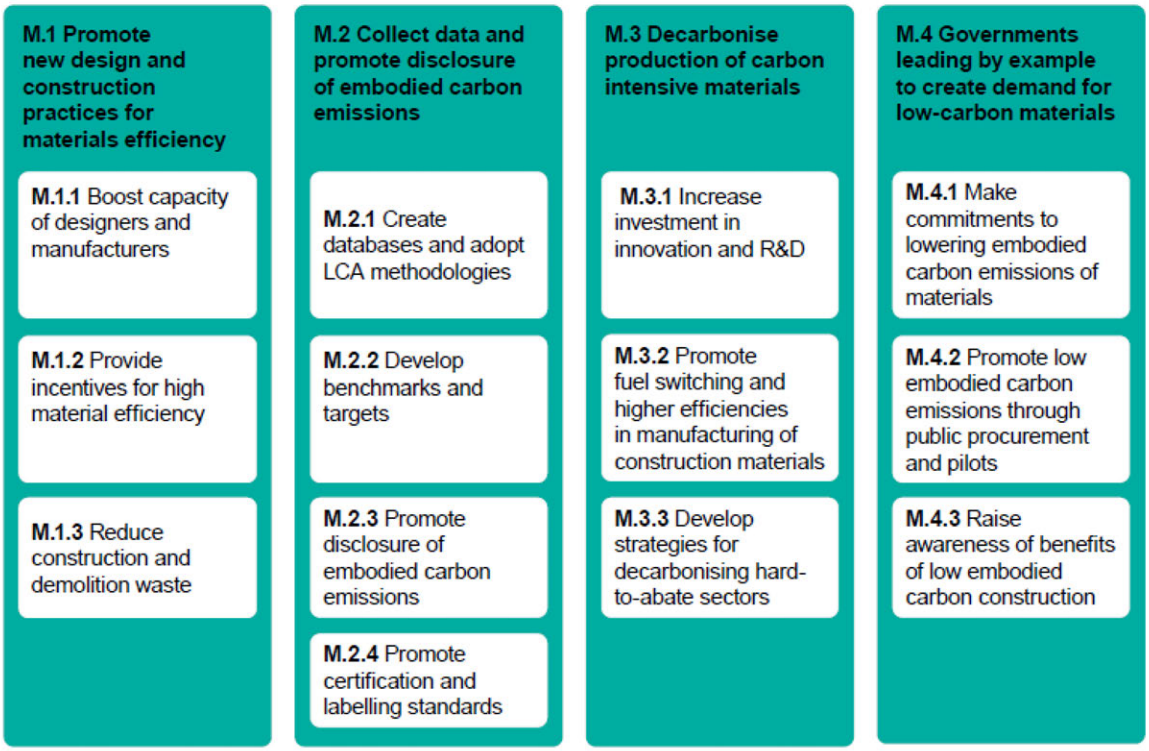


The Roadmap's strategy for reducing the embodied energy and embodied carbon emissions of building materials in ASEAN includes four key actions in the area of Materials (M):

1. Promote new design and construction practices for material efficiency.
2. Collect data and promote disclosure of embodied carbon emissions.
3. Decarbonise production of carbon-intensive materials.
4. Governments lead by example to create demand for low-carbon materials.

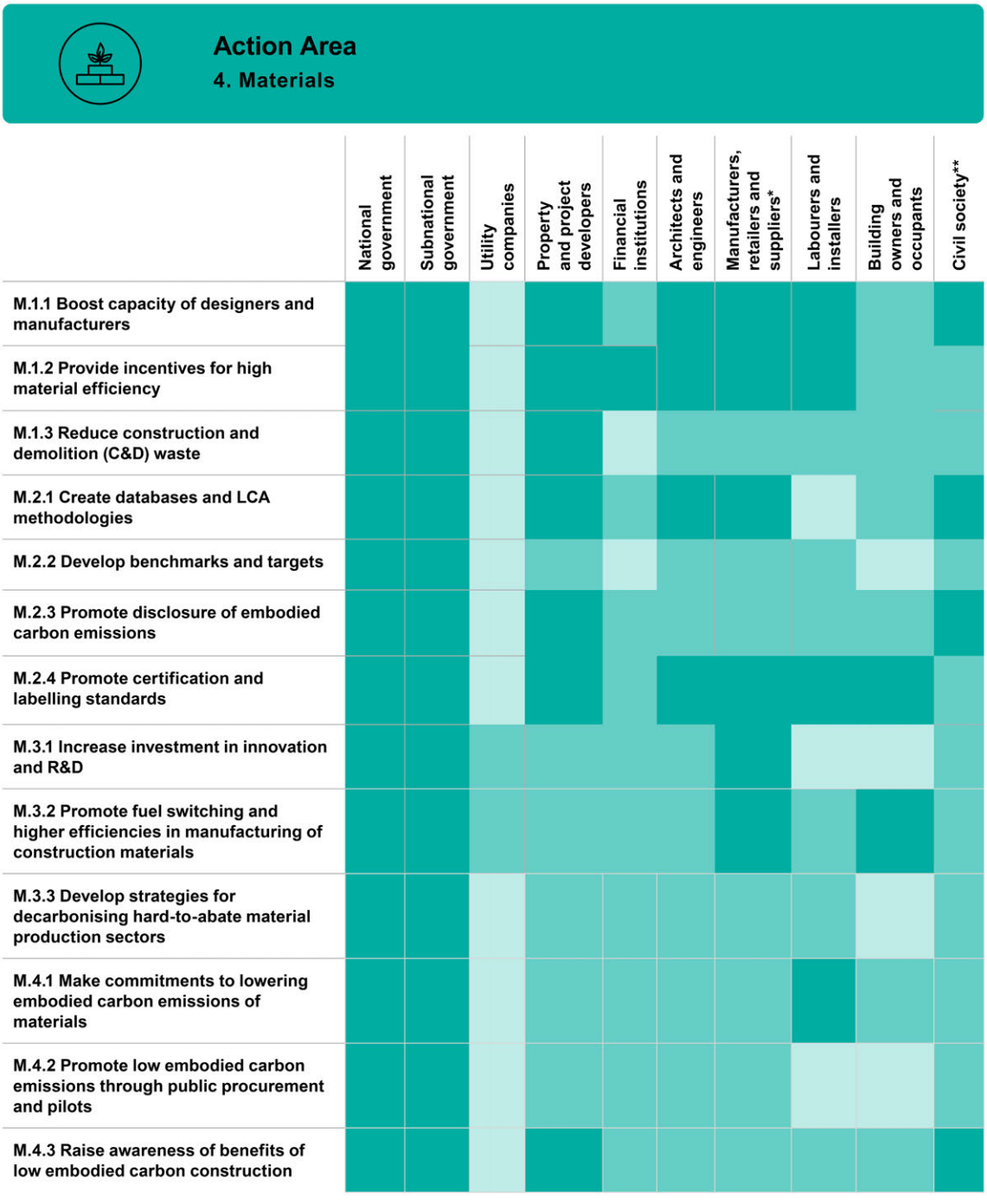
Within these Actions the Roadmap suggests thirteen Activities (e.g. M.1.1, M2.2, etc.) related to materials.

Summary of Roadmap strategy for Materials



As multi-stakeholder collaboration is one of the overarching principles of this Roadmap, it is important to consider which stakeholder groups could be involved in the delivery of each activity. Various stakeholder groups should be involved in the activities under the Materials action area in order to ensure their effective implementation.

Stakeholder mapping for Materials



*of appliances and materials. Includes product testers and certifiers.

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

Note: The darker the colour, the higher the importance of that stakeholder group for the activity and the more essential the group is for the activity's effective implementation.

Actions, Activities and Timelines

M.1: Promote new design and construction practices for material efficiency

M.1.1. Boost capacity of designers and manufacturers	**Current status:** Minimal adoption of local low-carbon materials or techniques for material efficiency, which includes designing for long life, flexibility, deconstruction, light weighting, etc.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Training strategy is developed to build capacity of designers and manufacturers on designing for low embodied carbon emissions. Develop guidelines for applying material efficiency principles to common building types, including high-density housing.	Guidelines for reducing the embodied carbon emissions of new constructions mainstreamed across all sectors, enabling a 50% reduction in embodied carbon emissions.	Principles for low embodied carbon design are mainstreamed among building designers and manufacturers of building components to enable net zero embodied carbon emissions for new buildings.
M.1.2. Provide incentives for high material efficiency	**Current status:** No specific incentives for material efficiency identified, though materials measures are common in green building certification programmes.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Incentives for re-use and recycling of materials and components, for building lifetime extension etc. in all countries. Promote intensified use of existing assets (i.e. limit building vacancy, favour mixed uses).	Incentives linked to performance standards for embodied carbon emissions.	Material efficiency optimised to zero- carbon across all sectors.
M.1.3 Reduce construction and demolition (C&D) waste	**Current status:** Variation in practices to reduce C&D waste, low use of circular economy principles, though commonly included in criteria for green building certification programmes.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	All building codes to include mandatory measures to reduce C&D waste.	Recycling and reuse of materials are mainstream and reach 40% for materials, e.g. glass, steel and composite wood products. Reduction of on-site C&D waste of 30%.	Recycling and reuse of materials are mainstream and reach 60% for building materials, glass, steel and composite wood products. Reduction in total amount of C&D waste to 50%.

Near-term recommendations to promote new design and construction practices for material efficiency

Boost capacity of designers and manufacturers

- 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 emissions.
- Include how to assess embodied carbon emissions, how to use Environmental Product Declarations, how to perform LCAs, how to adapt design and construction techniques to lower embodied carbon emissions in construction, how to achieve high-density developments without relying on tall structures (i.e. reducing reliance on concrete and steel); 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.
- Develop a network/group of green material providers across and beyond the region that could focus on increasing the availability of more affordable materials to ASEAN markets.
- Provide training on how to comply with policies such as labelling, Environmental Product Declarations, disclosure and LCA. Develop educational programmes including primary, secondary, vocational, university and adult education, to enable increased knowledge of sustainable building materials.
- Develop accreditation systems for professionals with these design skills.
- Training of product/material manufacturers:
- Provide training to industry regarding how to decrease the embodied carbon emissions of materials, 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 to increase recycling and reuse, and other circular design principles.
- Provide training on how to comply with policies regarding labelling, Environmental Product Declarations, disclosure.
- Topics to cover in capacity building: light weighting structures; achieving high-density developments without relying on tall structures (i.e. reducing reliance on steel and concrete); using appropriate LCA tools and methodologies.

Provide incentives for high material efficiency

- 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.
- Encourage reliance on recycled or repurposed materials in the construction of new buildings: Support the development of material reuse and recycling processes that

can reduce the life cycle embodied energy and emissions and increase the use of repurposed materials in product manufacturing and in building and construction projects.

Reduce construction and demolition waste

- Incentivise repurposing of buildings rather than demolishing of them, as well as reusing and recycling of building waste at the end of buildings' lifetimes. 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.

Examples

- **Singapore prefabricated materials:** Prefabricated materials are being used in Singapore to reduce construction time, increase productivity and reduce waste. Singapore's use of prefabricated prefinished volumetric concrete for the Brownstone Executive Condominium meant55 000 fewer man- days, increased "productivity and efficiency by 40%" and also increased safety and reduced waste and dust (Singapore BCA, 2021).
- **Singapore Green Buildings:** Singapore has been adopting measures to increase the use of recyclable materials and green technologies since 2005. For example, Eunoia Junior College was built using a Mass Engineered Timber system, for which the wood is extracted from sustainably managed forests, and has a smaller carbon footprint than other materials such as steel and carbon. Another example is the 11 Tampines Concourse, a commercial building that was built using improved concrete, which has less sand in its composition, being replaced by copper slag, recycled concrete aggregates and ground granulated blast furnace slag.
- **Thailand**: High efficiency building materials are promoted through the Energy Saving Label Programme under DEDE. The building materials that have labels include fibre glass insulation, glass, film, paint, roof tiles and bricks.

M.2: Collect data and promote disclosure of embodied carbon emissions

M.2.1. Create databases and adopt LCA methodologies	**Current status:** Minimal LCA assessments, partly due to a lack of data. No local or regional LCA methodologies or tools.		
	By 2025:	**By 2030:**	**Towards net zero- carbon**
	Develop regional methodology for assessment of whole life carbon emissions, prioritising most common construction materials and most promising alternatives. LCA required in all green building certification systems.	Incrementally increase the accuracy/detail of LCA calculations as data become available.	Mandatory whole-building LCAs for all new projects and major renovations.
M.2.2. Develop benchmarks and targets	**Current status:** Very few countries have minimum environmental standards for building materials or benchmarks of embodied carbon emissions per building type. Some green building certification includes the assessment of materials.		
	By 2025:	**By 2030:**	**Towards net zero- carbon**
	Benchmarking methodology is developed for building types based on LCA methodologies.	Embodied carbon emission benchmarks developed to inform certification and labelling programmes.	Embodied carbon emission benchmarks for all building types and countries drive continuous improvement.
M.2.3. Promote disclosure of embodied carbon emissions	**Current status:** Minimal disclosure of total embodied carbon emissions of building projects. Very little data available on disclosed embodied carbon.		
	By 2025:	**By 2030:**	**Towards net zero- carbon**
	Reporting system and open access database for assessment of embodied carbon of components and projects, feeding benchmarking and LCA tools. Requirements for disclosure in green building certification standards included.	Disclosure of embodied carbon emissions enabling the creation of benchmarks is mainstream.	Mandatory disclosure of embodied carbon emissions for continuous improvement of benchmarks.

M.2.4. Promote certification and labelling standards	**Current status:** Minimal use of labels for embodied carbon emissions or environmental impacts of materials such as Environmental Product Declarations.		
	By 2025:	**By 2030:**	**Towards net zero- carbon**
	Environmental Product Declarations and mandatory labelling for main materials and components. Requirements included in green building certification standards.	Labelling and certification for all materials/components in all countries.	Widespread use of environmental impact labels of materials and components.

Near-term recommendations to support collection of data and promotion of disclosure of embodied carbon

Create databases and adopt methodologies to enable LCA

- Review existing LCA methodologies for assessing embodied carbon in building projects. Identify the most suitable ones for the national context and recommend them for utilisation at the national, subnational and local levels.
- Regional cooperation for development of LCA methodology for embodied carbon emissions could be particularly effective, save time and resources, and improve data quality.
- Include the requirement of LCAs in green building certification and labelling programmes.

Develop benchmarks and targets

- Develop a database, such as for material inventories and accounting systems that can be accessed by all relevant stakeholders and that allows comparisons and calculations, which can be an important first step in tackling embodied emissions. Develop guidance on the use of methodologies and standards for making calculations and assessments.
- Develop benchmarks and targets by building type and by sector, based on data collected through disclosure programmes. Ensure regular revision and update of benchmarks and targets, which are based on regular updating of materials databases.

Promote disclosure of embodied carbon

- Develop reporting systems and open access databases for assessment of embodied carbon of components and projects, feeding benchmarking and LCA tools.
- Include requirements for disclosure in green building certification standards.

- Include embodied carbon emissions disclosure in submission to ASEAN Energy Awards Energy Efficiency, Green Building and Zero Energy Building award categories, and eventually a category for net zero-carbon buildings over their life cycle

Promote certification and labelling standards

- Develop mandatory labelling for main materials and components of building projects.
- Include requirements for materials with low embodied carbon into green building certification standards.

Examples

- Malaysia Green Performance Assessment System: The Green Performance Assessment System (GreenPASS) was developed by the Construction Industry Development Board (CIDB) in 2012 to focus purely on the environmental impacts of carbon emissions from buildings' construction and operation. GreenPASS is also known as Construction Industry Standard, CIS 20:2021. It includes a component on materials with the aim to reduce the environmental impacts of buildings through the use of materials with low embodied carbon (CIDB, 2021).

M.3: Decarbonise production of carbon-intensive materials

M.3.1. Increase investment in innovation and R&D	**Current status:** Low levels of investment in R&D into low-carbon materials and resource efficiency, new materials and manufacturing processes.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Increased regional collaboration for low-carbon materials and construction techniques. Collaboration on developing a strategy for the role of new technologies.	Continued regional collaboration on innovation.	Coordinated investment and regional collaboration for continued innovation and market development.
M.3.2. Promote fuel switching and higher efficiencies in manufacturing of construction materials	**Current status:** Manufacturing processes which are energy-intensive and reliant on fossil fuels are widespread with heavy reliance on imported goods for construction materials.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Development of strategies for the decarbonisation of heat, e.g. using biomass waste, waste heat recovery, heat pumps, solar thermal and geothermal heat.	Development of the use of local biomass waste where appropriate and waste heat recovery for processes. Electrification of processes.	Reduction in CO_2 from energy use in material production from current levels in alignment to net zero-carbon.

	Accelerated rollout of audits and energy management systems to optimise energy efficiency in industry.	Support for local supply of materials to reduce transport-related emissions. Encouragement of a switch from cement and steel to locally-sourced bio-based material production, which is less carbon intensive. Adoption of current building assessment tools (BAT) in all sectors, as well as EMS (energy management systems) and energy networks to share knowledge and experiences.	
M.3.3. Develop strategies for decarbonising hard-to-abate material production sectors	**Current status:** There is limited investment in decarbonising low-cost materials that are used for high-rise density building types.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Develop national decarbonisation roadmaps for steel and cement, including the potential for carbon capture utilisation and storage, as well as hydrogen.	Specific dates and targets for decarbonising key subsectors as appropriate to the national context for: steel, cement, aluminium and glass.	Established supply chains to improve availability of low-cost low-carbon materials.

Near-term recommendations to support the decarbonisation of the production of carbon-intensive materials

Increase investment in innovation and R&D

- Develop measures to enable and support basic and applied research into low-carbon, bio-based and locally-sourced 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

Promote fuel switching and higher efficiencies in the manufacturing of construction materials

- 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.

- Support establishment/engagement of material development/ testing facilities/laboratories through innovative academic and private sector actors and engaging official product and material certification bodies.

Develop strategies for decarbonising hard-to-abate material production sectors

- Implement policies that enable improved design and purchasing decisions based on embodied carbon emissions and energy. This could be achieved by 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 rely on low-carbon and efficient materials based on LCAs.

M.4: Governments leading by example to create demand for low-carbon materials

M.4.1. Make commitments to lowering embodied carbon emissions of materials	**Current status:** Few requirements for assessment, disclosure, or reduction in total embodied carbon of building projects.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Governments and companies to define targets for reduction in embodied carbon emissions in line with achieving net zero embodied carbon by 2050 or soon thereafter.	Target of 40% overall reduction in embodied carbon emissions of new construction compared to current levels.	Net zero embodied carbon emissions for most new buildings, and near zero embodied carbon for all new buildings.
M.4.2. Promote low embodied carbon emissions through public procurement and pilots	**Current status:** Few public procurement rules involving embodied carbon emissions.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	All federal public procurement using low-carbon materials as a requirement within tendered contracts. At least one zero whole life carbon emissions demonstration project in each AMS, with extensive data collection plan for evidence of benefits and costs.	All public procurement using zero embodied carbon emissions within tendered contracts.	Supply chains and markets for low-carbon materials established for public and private procurement.

M.4.3. Raise awareness of benefits of low embodied carbon construction	**Current status:** Minimal awareness of the benefits of low-carbon techniques or materials.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Collect data on the benefits of low-carbon construction as relevant to citizens, local governments and industry.	Key materials for achieving net zero embodied carbon emissions identified and mainstreamed. Strong awareness campaigns based on collected evidence from pilots.	Continuous awareness raising which showcases the multiple benefits of low-carbon emissions construction so that it is viewed as the norm.

Near-term recommendations to support governments leading by example to reduce embodied carbon of materials

Make commitments to lowering embodied carbon of materials

- Require embodied carbon emissions assessments or LCAs to be undertaken on all new major and public investments. Require public bodies to disclose information on portfolio and/or asset-level embodied carbon emissions. Provide financial products to investors to incentivise low-carbon projects and business models, and support the use of preferential loans or mortgages to stimulate a market for low-carbon materials.

Promote low-carbon public procurement and pilots

- Integrate considerations of embodied carbon emissions in planning and building regulations, require disclosure for all new construction and for large renovation projects, initiate low-carbon materials pilot projects and provide development incentives to project developers (see UP 2.1).
- Include requirements in public tendered contracts to use low-carbon materials for public procurement.

Raise awareness of the benefits of low embodied carbon construction

- Provide information and raise awareness. Promote capacity building on low-carbon materials and technologies (e.g. bio-based materials such as wood, bamboo, straw and earth constructions and 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 using low-carbon materials and raise awareness.
- Provide training to government agencies about collecting data on embodied carbon emissions of materials and building projects, and training on the development of an integrated policy portfolio towards zero embodied carbon emissions buildings and construction. Provide training on how to develop

information and assessment tools for project developers, designers and consumers such as embodied carbon emissions 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.

Examples

- **Thailand Green Public Procurement Programme:** The promotion of the Green Public Procurement Plan (GPPP) in the Government of Thailand started in 2005 with the Pollution Control Department of the Ministry of Natural Resource and Environment commencing the development of Green Public procurement criteria for 14 products and 3 services that are commonly used by government agencies. The 2nd GPPP (2013-2016) focused on increasing adoption of green procurement in government units, supporting the private sector to increase availability of green products on the market and promoting behaviour change among consumers. The programme is promoted by the Pollution Control Department, Ministry of Natural Resources and Environment. According to the Pollution Control Department, there are currently 37 product categories in the GPP list, and approximately 1 400 products in the GPP database. A draft National Action Plan on Promoting GPP (2021-2027) has been in the approval process.
- National building materials industry in Indonesia: The Indonesian building materials industry produces lightweight bricks or (autoclaved aerated concrete) that can be used in high-end buildings. The manufacturing process uses German standards and the lightweight bricks have many advantages. For example, autoclaved aerated concrete helps the building to be more resistant to shocks during an earthquake, because it is a lighter material, making the weight of the structure lower. The market for ecological products is growing in Indonesia. The ecological product certification Green Label Indonesia is given to products and materials that have met the criteria required by an audit, and provides a label that can be easily identified in the market.

Tracking Progress

Indicators are an important tool for understanding the changes in conditions that affect whether progress towards a target of net zero-carbon buildings and construction is being made.

For materials, indicators are important in tracking policies that seek to reduce embodied carbon, such as setting minimum standards for embodied carbon, and awarding embodied carbon within building performance certificates. In addition, tools and information such as the application of LCA methods, data sharing and registry of projects with low-carbon specification, are important elements to understand whether construction materials are fostering the movement to zero-carbon buildings.

Potential indicators for tracking progress at a national scale may include:

- [M.1.1] Number of certified low-carbon materials by material types.
- [M.1.1] Percentage or number of accredited professionals (and/or tools) for assessing whole life carbon emissions.
- [M.1.1] Presence of requirements for low-carbon materials in green building certifications, adopted in progressive 'stretch' codes, and in regulations.
- [M.1.2] Availability/Amount of incentives offered for use of low-carbon materials.
- [M.1.3] Presence of requirements for construction and demolition waste minimisation, recycling and reuse in certifications, adopted in stretch codes, and in regulations.
- [M.2.1] Presence of databases for low-carbon materials and LCA methods.
- [M.2.2] Presence of benchmarks for low-carbon materials using comprehensive LCA methods.
- [M.2.3] Presence of disclosure requirements in certifications, adopted in stretch codes and in regulations.
- [M.2.4] Proportion of/Number of buildings using certifications with LCA requirements.
- [M.3.1] Amount spent on research and development of zero-carbon materials.
- [M.3.2] Presence of strategies and policy frameworks for decarbonising manufacturing and construction materials used in buildings.
- [M.3.3] Presence of strategies and policy framework for decarbonising hard-to-abate material production sectors.
- [M.4.1] Presence of commitments to lower embodied carbon emissions from materials, their level and target dates.
- [M.4.2] Presence of public procurement procedures and tender rules that require utilisation of low-carbon materials in construction and renovation projects.
- [M.4.2] Presence/Number of projects that comply with public procurement procedures and tender rules that require utilisation of low-carbon materials in construction and renovation projects.
- [M.4.3] Level of awareness of benefits of low-carbon construction measured through surveys of construction professionals.

Action Area 5: Systems and operations

Introduction

While the delivery of zero-emission, efficient and resilient new or renovated buildings is essential, it is equally important to ensure that buildings systems are efficient and operating according to their manufactured specifications. Energy-consuming lighting, appliances and equipment systems commonly have a shorter lifetime than the buildings themselves and offer significant opportunities to reduce emissions in new and existing buildings.

In addition, adjustments of user behaviour and a building's operations management influence the energy and emissions performance of a building by determining whether systems are optimised to deliver their service only when required, for example by providing cooling and lighting only when spaces are occupied, or if they inefficiently waste resources, for instance by operating air conditioners at temperature set points that are lower than needed.

To achieve sustainability over its lifetime, a building needs to be operated and maintained appropriately throughout. Adequate operation and maintenance result not only in energy savings, but also increased quality of the internal environment, promoting health, well-being and productivity. They also facilitate maintenance procedures, enabling a longer life of the buildings and their components.

Vision for systems and operations

Energy-efficient systems and modes of operations that not only increase comfort, but reduce energy bills and emissions. are widely adopted.

Current context

The number of energy and building managers across ASEAN with a focus on improving energy performance is growing. In 2016, there were around 12 000 certified energy managers and an identified need of an additional 6 000,especially in Indonesia, Malaysia, Thailand and Viet Nam.

Across the AMS, as noted in the New Buildings section, there are numerous building rating and certification schemes. Building systems performance,

operation and maintenance, commissioning, sub-metering and calibration, energy monitoring controls, and building system automation are among the main criteria utilised in these rating schemes.

In terms of policies and regulations (see Table below) there are a number of policies that focus on minimum energy performance standards (MEPS) for building systems, in particular air conditioning. However, there are minimal policies regarding building operation and maintenance in the region that seek to ensure systems are maintained.

A challenge that must be overcome within the AMS is the improvement in the energy efficiency of air conditioners. The IEA projects that under current stated policies, efficiencies are expected to change very slowly and reach only 5 W/W to 6 W/W SEER (Seasonal Energy Efficiency Ratings) by 2050, (Future of Cooling in Southeast Asia [IEA, 2019b]). Appliances with efficiency higher than 6 W/W are already available today, and in some markets are no more expensive than the average available. The Future of Cooling in Southeast Asia estimates that in order to accommodate the expected rise in cooling demand and stay on track towards climate goals, the global average efficiency of air conditioners in the region will have to reach over 9 W/W SEER by 2050. This gap suggests that much work needs to be done in this area (see the Roadmap towards Sustainable and Energy-efficient Space Cooling in ASEAN).

Through the ASEAN SHINE programme, support for aligning standards for appliances is being addressed and efforts through harmonisation of standards for air conditioners for energy performance testing (ISO 5151:2010) and testing laboratories on ISO/IEC 17025 are made.

With most of Southeast Asia's building energy consumption is projected to be from appliances and air conditioning (IEA, 2019c) user behaviour plays a significant role in ensuring that these systems are used efficiently.

Current status of policies for sustainable systems and operation

Country	Smart and digital systems policies	MEPS and Labelling (S&L) Policies	Energy management
Brunei Darussalam		Standards and Energy Labelling for Products and Appliances (under development)	Energy Management Policy in government and commercial sector in development

Country	Smart and digital systems policies	MEPS and Labelling (S&L) Policies	Energy management
Cambodia		Adopted regional MEPS for air conditioners and labelling for energy-efficient appliances in Phnom Penh to be fully adopted by 2026	
Indonesia	100 Smart City Movement (in force 2017-2019) included incentive plan for smart buildings, especially cooling and lighting systems	MEPS and energy efficiency labels for AC were updated in 2021 MEPS and star ratings for refrigerators, fans, rice cookers were established in 2021 MEPS for different lamp categories are under development Minister of Energy and Mineral Resources Regulation No. 14 of 2021 concerning the application of minimum energy performance standards for energy-consuming equipment	Large energy users (>6000 toe per annum) are obliged to implement energy conservation measures through energy management. Government Regulation No. 70/2009 Standards and the implementation phase of energy efficiency measures in buildings. Minister of Energy and Mineral Regulation No.14/2012 on Energy Management
Lao PDR		MEPS for AC is under development	
Malaysia	Smart Cities Framework Malaysia	Adopted regional MEPS for air conditioners. Mandatory MEPS: AC, refrigerators, fans, lighting.	Voluntary standard based on international standard (ISO) for energy management systems (MS ISO 50 001:2011)
Myanmar		National Policy Roadmap. Adopted regionally harmonised technology neutral and mandatory MEPS. Adopted (ISO 16358) testing standards in 2020. Established national system for MV&E	Voluntary standard based on international standard (ISO) on energy management systems (MMS ISO 50 0001:2011)
Philippines	Philippines Energy Plan 2016-2030 to focus on promoting smart energy consumers and smart technologies as a core strategy.	Adopted regional MEPS for Air Conditioners Energy Efficiency and Conservation Act (Republic Act No. 11285 of 2018) requiring manufacturers, importers and dealers to comply with the Minimum Energy Performance Standards (MEPS) and to display the Energy Label showing the energy requirements and consumption efficiency. The Act covers lighting, air conditioners, refrigerators, TVs and washing machines	

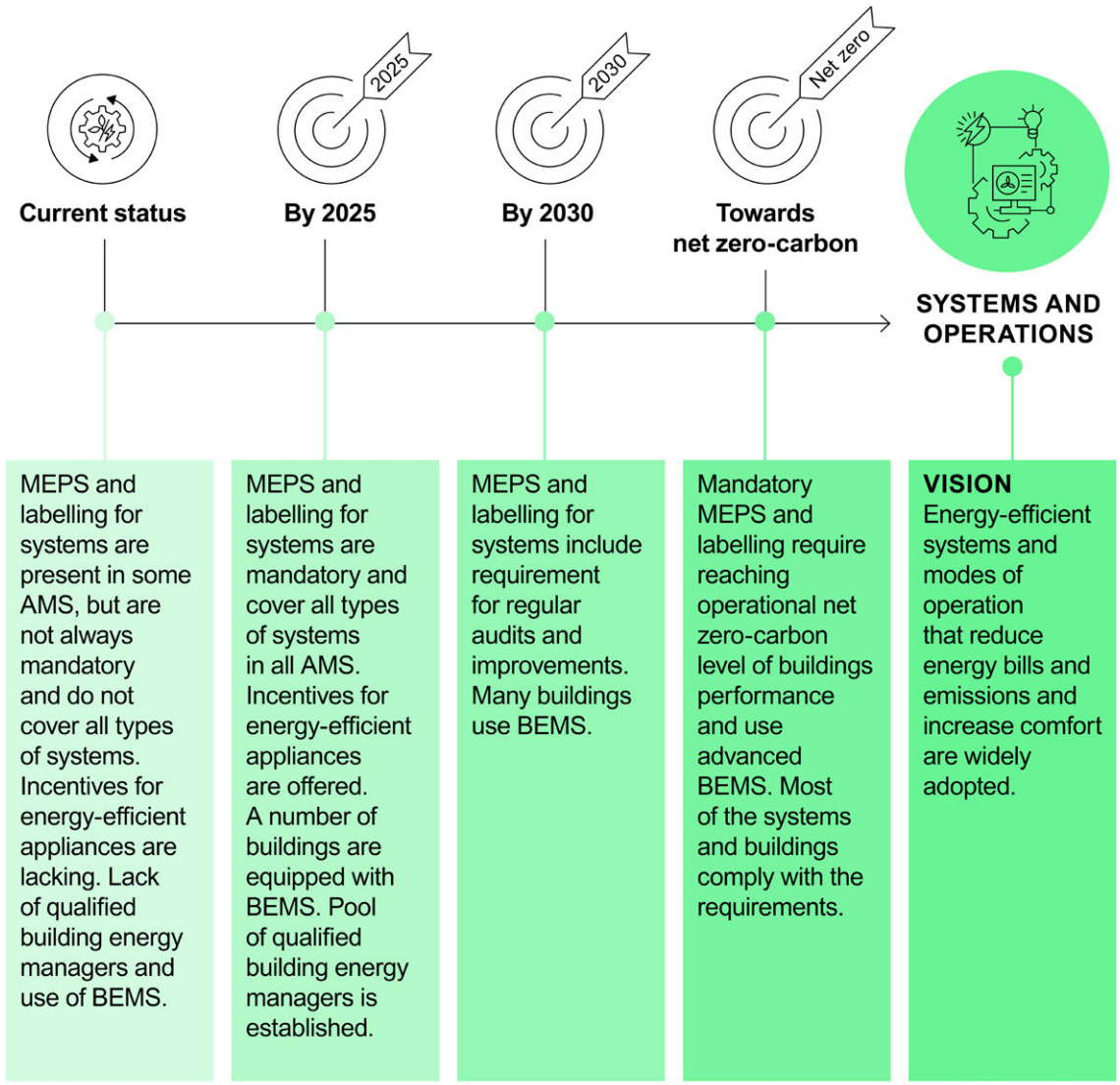
Country	Smart and digital systems policies	MEPS and Labelling (S&L) Policies	Energy management
Singapore	Super Low Energy Building Technology Roadmap examines "a wide spectrum of emerging energy technologies, analyses their interaction and integration", and explores their feasibility in the tropical urban context.	Mandatory labelling of lighting, air conditioners, refrigerators, clothes dryers.	Energy management systems SS ISO 50001: 2018 based on international ISO specifies the requirements for establishing and maintaining energy management systems.
Thailand	Maintenance and operation performance in Thai's Rating of Energy and Environmental Sustainability (TREES) (TGBI, 2017); Smart grid policy advised for renewable energy progress (in development); Thailand 4.0 to deliver on smart energy goals (in development); Smart City Development	Adopted regional MEPS for air conditioners; Mandatory MEPS: fans, refrigerators, and lighting. DEDE and EGAT (the Electricity Generating Authority of Thailand) set out High Energy Performance Standard (HEPS) (Voluntary programme)	Mandatory energy management system requiring designated buildings to conduct energy management and assign an energy manager, with reports to be submitted to DEDE yearly.
Viet Nam	7th Power Development Plan (PDP VII) calls for the introduction of modern technologies to improve reliability of grid and quality control, increase renewable energy use, and promote demand-side management	Mandatory MEPS and labelling: AC, fans, refrigerators, washing machines, kettles, laptops, electric cookers, televisions, lighting, several types of office and commercial equipment	Designated industrial energy and commercial energy users (e.g. factories, supermarkets, hotels and office buildings) of >750kVA are required to establish an energy management system and report energy reduction plans Law No. 50/2010/QH12 of 2011 on Economical and Efficient Use of Energy requires industrial producers to incorporate energy management programmes within their programmes on quality control.
ASEAN		Regional MEPS action plan to promote harmonisation and Promotion of Energy Efficiency Standards and Labelling on Air conditioning and Lighting products. ASEAN countries to notify a minimum energy efficiency ratio (EER) of 2.9W/W or cooling season performance factor (CSPF) of 3.08W/W by 2020 as mandatory MEPS for all	

Country	Smart and digital systems policies	MEPS and Labelling (S&L) Policies	Energy management
		fixed and variable drive ACs below 3.52kW capacities. The MEPS would be periodically reviewed and revised at an interval of five years or less.	

Note: Blank areas of the table indicate that no relevant information was found during data collection.

Summary of strategy for systems and operations

Summary of milestones for Systems and Operations towards net zero-carbon

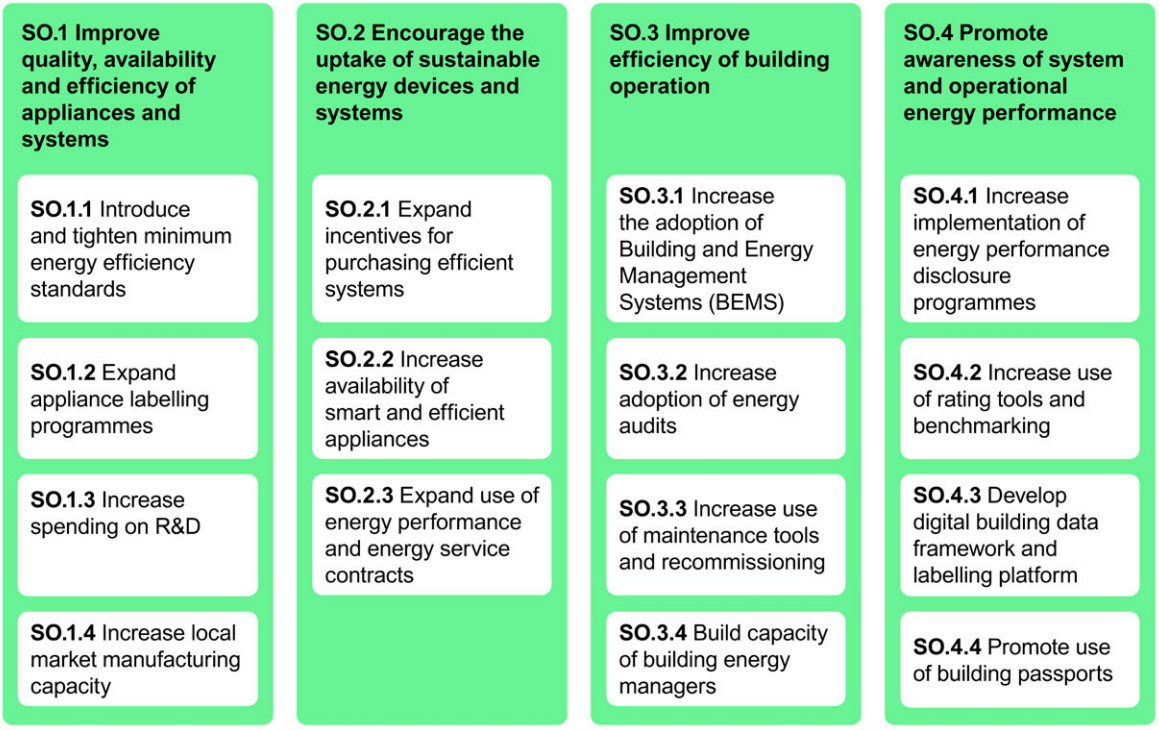


The Roadmap's strategy for advancing energy efficiency in the operation of buildings and their systems in ASEAN includes four key actions in the area of Systems and Operations (SO):

1. Improve quality, availability and efficiency of appliances and systems.
2. Encourage the uptake of sustainable energy devices and systems.
3. Improve efficiency of building operations.
4. Promote awareness of system and operational energy performance

Within these Actions, the Roadmap suggests fifteen Activities (e.g. SO.1.1, SO.2.2, etc.) related to systems and operations.

Summary of Roadmap strategy for Systems and Operations



As multi-stakeholder collaboration is one of the overarching principles of this Roadmap, it is important to consider which stakeholder groups could be involved in the delivery of each activity. Various stakeholder groups should be involved in the activities under the Systems and Operations action area in order to ensure their effective implementation.

Stakeholder mapping for Systems and Operations

Action Area

5. Systems and Operations

	National government	Subnational government	Utility companies	Property and project developers	Financial institutions	Architects and engineers	Manufacturers, retailers and suppliers*	Labourers and installers	Building owners and occupants	Civil society**
SO.1.1 Introduce and/or tighten minimum energy efficiency standards										
SO.1.2 Expand appliance labelling programmes										
SO.1.3 Increase spending on research and development (R&D)										
SO.1.4 Increase local market manufacturing capacity										
SO.2.1 Expand incentives for purchasing efficient systems										
SO.2.2 Increase availability of smart and energy efficient systems & appliances										
SO.2.3 Expand use of energy performance and energy service contracts										
SO.3.1 Increase the adoption of Building and Energy Management Systems										
SO.3.2 Increase adoption of energy audits										
SO.3.3 Increase use of maintenance tools and recommissioning										
SO.3.4 Build capacity of building energy managers										
SO.4.1 Increase implementation of energy performance disclosure programmes										
SO.4.2 Increase use of rating tools and benchmarking										
SO.4.3 Develop digital building data framework and labelling platform										
SO.4.4 Promote use of building passports										

* of appliances and materials. Includes product testers and certifiers.

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

Note: The darker the colour, the higher the importance of that stakeholder group for the activity and the more essential the group is for the activity's effective implementation.

Actions, Activities and Timelines

SO.1: Improve quality, availability and efficiency of appliances and systems

SO.1.1. Introduce and tighten minimum energy efficiency standards	**Current status:** Most of the AMS have mandatory and voluntary minimum energy performance standards (MEPS) for most appliances. Performance levels for national standards are unequal in meeting latest international standards of energy performance. Not all systems are covered.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Most appliances and systems are covered by mandatory MEPS and a progressive pathway is established to improve performance levels.	MEPS are increased in stringency by 50-100% in relation to 2020.	Mandatory. progressively stringent MEPS are implemented for all main types of appliances.
SO.1.2. Expand appliance labelling programmes	**Current status:** Some consumer awareness of labels across the region, but greater need for improved information on appliance and system performance. Many appliances have mandatory labels, though inefficient products are still widely available.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	All appliances and main building systems are covered by mandatory labels. Label levels are integrated with MEPS benchmarks with progressive strengthening of levels.	All appliances have mandatory labels with comprehensive information for consumers on energy performance. Performance labels are raised and reclassed based on MEPS.	Full use of labels for energy performance of appliances with mandatory phase out of products below a certain threshold for energy performance.
SO.1.3. Increase spending on R&D	**Current status:** Limited levels of investment in R&D of energy efficiency of appliances and systems within region. Low-cost appliances lack investment in energy efficiency and remain expensive.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Appliance manufacturers double their investments in energy efficiency R&D in relation to the 2020 level.	Manufacturers continue to invest in improving energy performance for low-cost appliances and systems.	Investment levels in efficiency R&D triple the levels from the 2020 baseline and all appliances are on a pathway to least cost high performance.

SO.1.4. Increase local market manufacturing capacity	**Current status:** There are now levels of local energy-efficient appliances and systems manufacturing across the AMS, though high-end products are developed to compete with international products.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Promote local appliance manufacturing to prioritise low-cost higher performance products through incentives (e.g. grants, development tax, fiscal incentives, specific loans, etc.).	Enhance incentives for regional trade of local manufacturing and high efficiency appliances.	Strong local marked manufacturing of high energy performing appliances and systems.

Near-term recommendations to support availability and efficiency of appliances and systems

Introduce and tighten minimum energy efficiency standards

- Establish a taskforce for appliance energy improvement that brings together and challenges appliance manufacturers to find new and cheaper ways to improve efficiency and generate economies of scale.
- Develop regional testing laboratories and adopt mutual recognition agreements**.** Local manufacturers require certification testing of appliances by independent testing labs in order to determine the appliance performance levels. Develop partnerships between government and industry to develop testing labs for industry use.
- Implement the ASEAN Product Registration System to monitor the compliance with standards and labelling. Support the exchange of product information databases with other AMS to support the MEPS harmonisation in the region, such as through the Product Registration System developed by ACE and UNEP for appliances in ASEAN.

Increase participation in appliance labelling programmes

- Develop national energy efficiency standards and labelling programme frameworks for each AMS with a focus on establishing or expanding appliance rating labels and endorsement labels for appliances and systems.
- Align performance levels of the labelling system with MEPS and ensure that both are regularly updated.

Increase local market manufacturing capacity

- Provide incentives to improve energy performance of locally-manufactured appliances, for instance through VAT rebates, conditional grants or loans, or R&D tax incentives.

Examples

- **Viet Nam MEPS Requirements:** Viet Nam has implemented mandatory MEPS and labelling for a range of appliances, including lighting, refrigerators, washing machines, televisions, rice cookers and fans. Viet Nam provides tax incentives for businesses manufacturing energy-efficient appliances and equipment, an initial exemption from corporate tax and then a 50% rate for two to three years.
- **Malaysia Sustainability Grants:** Malaysia announced the third phase of Sustainability Achieved via Energy Efficiency (SAVE 3.0), under which grants are being provided to the general public for the purchase of highly efficient appliances. This programme offers a RM400 (approximately ESD95) e-rebate for households to purchase energy-efficient appliances that received a 4- or 5-star energy efficiency label from the Energy Commission. The programme allows households to buy an energy-efficient refrigerator or air conditioner (maximum price of RM200) and also one of the following appliances: television, washing machine, microwave oven or rice cooker. The programme includes locally-manufactured refrigerators, air conditioners, washing machines and televisions.

SO.2: Encourage the uptake of sustainable energy devices and systems

SO.2.1. Expand incentives for purchasing efficient systems	**Current status:** Some incentives for purchasing specific high-performance systems exist for some building types in some AMS, and low-cost consumer appliances are typically not subject to performance improvement requirements or phase out.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	A stimulus scrappage scheme and subsidies, rebates, tax cuts, zero interest loans or grants for purchase of energy-efficient products for replacement of low-cost appliances are introduced.	Incentive scheme to focus on scrappage and replacements for low-income households and micro-financing for small businesses are introduced.	Strong adoption of efficient systems with targeted incentives for hard-to-reach households and small businesses is taking place.

SO.2.2. Increase availability of smart and efficient systems & appliances	**Current status**: Few buildings use digital sensors (e.g. smart meters) and controls in appliances and systems. High performance cooling and appliances have automatised and optimised controls and there is a small market of appliances using digital sensors and controls.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Standards for automation of cooling and ventilation systems and "eco-mode" scheduling have been developed. About half of all mid-range appliances use automated systems. Several member states are starting to adopt open standards for automated systems.	Most cooling and ventilation systems are automated. About half have automated and digital communication systems using open standards.	Automated building systems with digital sensors and controls are a common practice. Most automated and digital communication systems use open standards.
SO.2.3. Expand use of energy performance and energy service contracts	**Current status:** Some availability of ESCO (Energy Services Company) contracting among specific building types, particularly in high-end buildings, but there is limited financing and regulatory allowance for risk sharing. Emerging ESCO market among AMS with strong performance mandates.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Policy framework that supports ESCO opportunities is developed to focus on reducing financing and operation risks. ASEAN ESCO association is established to demonstrate projects for ESCO service models and to promote knowledge sharing.	The ESCO-related legislation is expanded and revised to reduce legal and financial barriers for ESCO operations.	Strong ESCO market is fully operational, supported through financial risk sharing and savings models.

Near-term recommendations to support the uptake of energy-efficient and low-carbon devices and systems

Expand incentives for purchasing efficient systems

- Increase partner participation and engagement**.** Establish government and industry initiatives that focus on providing the knowledge and tools needed to help design and adapt standards and labelling, procurement, and changes in policy support.

- Develop financial incentives provided by utilities and governments for consumers and appliance manufacturers to promote the purchase of highly efficient appliances.
- Establish policies for government procurement of highly efficient equipment and appliances and guidelines that also include energy efficiency among low-cost or local-content requirements.[17] Overcoming these barriers requires putting better information and tools in the hands of the officials making procurement decisions and overseeing those programmes.

Increase availability of smart and energy-efficient appliances

- The use of sensors and controls can assist with better management of key parameters of building operation, such as temperature, amount of lighting and intensity of ventilation. Installing energy metering and system controls, as well as linking them with the building's energy management system will enable better management of energy use and result in energy savings. Across the region, automated controls could be integrated into domestic appliances, such as air conditioning systems.

Expand use of energy performance / energy service contracts

- Develop a policy framework and simplified administrative procedures (where possible) to provide guidance on how to measure and verify energy savings achieved by ESCOs.
- Initiate energy efficiency projects in public buildings through ESCO companies to lead by example and demonstrate feasibility of such projects.

Examples

- **Thailand Internet of Things (IoT):** The Government Building Metering project implements the IoT by installing digital electricity meters and management systems to collect and analyse real-time electricity consumption data of buildings (such as their specific energy consumption), that can help to improve their energy efficiency (DEDE, 2012) The project was implemented in 2018 and included a subsidy programme for IoT technology for designated buildings and factories. The programme covered up to 20% of the total costs of the IoT system's installation (limited to THB 2 million – around USD 46 000). The payback maximum was seven years and there was a requirement for both monitoring and controls. During the project 2 146 digital meters were installed in 261 buildings (157 hospitals and 104 offices).

[17] Local-content requirements are policies imposed by governments that require firms to use domestically-manufactured goods or domestically-supplied services in order to operate in an economy. They are known to have costs and benefits that must be carefully considered.

- Smart cities in Thailand: The country aims to reach 100 smart cities by 2024 through the Thailand 4.0 initiative, which is geared to promoting and supporting innovation, R&D and superior and green technologies, with smart cities as a core pillar. The goal is to equip cities with sensors, integrated data systems and a building level digital twin to monitor and predict extreme weather events and natural disasters. From May to July 2020, 39 cities submitted proposals for evaluation and approval to the National Steering Committee on Smart City Development to join the scheme. The proposals were for established city areas to apply smart city goals: an infrastructure investment and a development plan, an implementation project for an open and secure city data platform, smart city solutions and a sustainable management model. An example of the initiative is Phuket – Thailand's first smart city. Local companies were encouraged to use sustainable energy because of the high demand in peak tourism periods. The city also worked in collaboration with the Electricity Generating Authority of Thailand (EGAT) to encourage efficient energy use and the switch to alternative sources such as solar photovoltaics.

SO.3: Improve efficiency of building operation

SO.3.1. Increase the adoption of Building and Energy Management Systems (BMS, EMS)	**Current status:** BMS systems are limited to high-end non-residential buildings and high-performance building systems in recently renovated developments across the AMS. Few buildings are using integrated optimised BMS and EMS.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	BMS and EMS are being used among larger and energy intensive buildings, such as hotels, hospitals and commercial offices.	Most large buildings use BMS and/or EMS.	Wide use of optimised BMS and/or EMS in all building types.
SO.3.2. Increase adoption of energy audits	**Current status:** Energy audits are limited across the AMS with some auditing undertaken for large buildings in few jurisdictions.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	A minimum size and energy use threshold for buildings' use are developed, above which buildings are mandated to undertake energy audits. Energy audits are required for public buildings at a regular interval (e.g. 3-4 years).	Large non-residential and residential buildings are required to undertake regular energy audits (e.g. every 3-4 years). Benchmark recommendations to promote voluntary improvements are set.	All non-residential and residential buildings are required to undertake regular energy audits (e.g. every 3-4 years). Benchmark recommendations for improvements are being implemented.

SO.3.3. Increase use of maintenance tools and recommissioning	**Current status:** Few buildings have robust operation and maintenance tools in place. There are some regulated services (i.e. gas appliances and hot water systems) in commercial or public buildings using operation and maintenance tools.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Open standards for operation and maintenance tools are developed and voluntary adoption through energy audit schemes is promoted. Use of operation and maintenance tools grows.	Operation and maintenance tools (including open standard digital tools) and registration requirement of tools for large buildings are widely used.	All buildings are equipped with operation and maintenance tools.
SO.3.4. Grow capacity of building energy managers	**Current status:** There is limited energy efficiency literacy among building managers and there are few certification schemes and training programmes for energy efficiency. There is a growing number of courses and industry-led programmes for building performance management.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Framework for industry and government-led training programmes for building energy managers is established.	Association of building energy managers and recertification standards are established.	Strong presence of highly skilled building energy managers and associations.

Near-term recommendations to support efficiency of building operations

Increase the adoption of Building and Energy Management Systems (BEMS)

- Within the commercial sector, advanced systems such as BMS and EMS (building and energy management systems [BEMS]) offer significant potential for reducing energy consumed in buildings, as well as for providing improved comfort and flexibility to the building users and facilitating maintenance. Training professionals to install and operate these systems is required to unlock the potential savings within the existing building stock. The use of EMS can facilitate the adoption of ISO 50001.
- The data collected by EMS and BMS systems also have the potential to enhance the building data stock quality, contributing towards benchmarking, labelling, certification or monitoring of buildings policies, and to enable energy management strategies such as those outlined in the ISO 50001 standard.

Increase adoption of energy audits

- Promote and, where relevant, mandate 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. The audits can also help collect valuable data about the building and equipment stocks.

Increase use of maintenance tools and recommissioning

- 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 and with moderation. This is particularly valid in the residential sector, where access to appliances and air conditioners is rising rapidly.

Build capacity of building energy managers

- Develop a framework for training as well as accreditation mechanisms for building energy managers.

Examples

- **Viet Nam incentives for energy efficiency**: Viet Nam provides tax incentives for businesses manufacturing energy-efficient appliances and equipment and renewable energy-consuming products to build manufacture facilities, as well as offers import duty exemptions and reductions for energy-efficient and renewable energy-consuming devices and equipment, which are not available domestically.
- Cambodia's first LEED-certified factory: A garment factory in Phnom Penh is Cambodia's first LEED-gold-certified factory, indicating that the sector can capitalise on the sale of carbon credits through the Climate Impact X (CIX) platform. Cambodia is committed to meeting the 2030 and 2050 carbon reduction targets, with green buildings and net zero-carbon buildings playing an important part to achieve this goal. The LEED Gold and Platinum buildings certification gives the opportunity to issue green bonds. The carbon savings can be converted into carbon credits and traded, for example on the CIX exchange. In the period of 2016-2020, the government of Cambodia sold nearly 10 million tonnes of carbon credits.

SO.4: Promote awareness of system and operational energy performance

SO.4.1. Increase implementation of energy performance disclosure programmes	**Current status:** There is some disclosure of operational performance among the AMS mainly for large buildings. Overall, few countries require energy use disclosure.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Policy framework and legislation for voluntary performance disclosure for large buildings and specific sectors are developed. Disclosure of energy use is required for all public buildings.	Disclosure of energy use is mandatory for all large residential and non-residential buildings.	Disclosure of energy use is mandatory for all residential and non-residential buildings performance with wide consumer awareness of programmes.
SO.4.2. Increase use of rating tools and benchmarking	**Current status:** Voluntary benchmarking programmes are used in few AMS and overall demand for energy benchmarking is low.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Voluntary system for energy benchmarking for large commercial buildings is established. All public buildings are rated and benchmarks are published for comparison.	Mandatory system for energy benchmarking is adopted for all large buildings.	Benchmarking tools are available and widely used in all building types.
SO.4.3. Develop digital building data framework and labelling platform	**Current status:** There is limited building energy performance data sharing or access across the AMS. There is a broad lack of data infrastructure to support repositing and sharing of buildings' data and energy performance.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	National data framework protocols for collecting and reporting building characteristics and performance are established.	Open data framework is in place for building data repositing and access to non-sensitive mandatory minimum details registered for all buildings.	Digital lodgement and exchange for building characteristics and energy performance are established.

SO.4.4. Promote use of building passports	**Current status:** Limited voluntary and silo information collection. Little life-course data collection on building construction, operation and deconstruction.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Voluntary requirements for building passports with appropriate legislation and standards for digital passport data storage and sharing are established. All public buildings to have a Phase 1 building passport.[18]	Requirements for all large buildings to have building passports with energy data; requirements for their biannual update are introduced. All public buildings to have Phase 2 building passport with high resolution data.	Use of comprehensive building passports and their regular update are mandatory for all buildings.

Near-term recommendations to support awareness of building system operation performance

Increase implementation of energy performance disclosure programmes

- 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.

Increase use of rating tools and benchmarking

- Various 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.

Develop digital building data frameworks and labelling platforms

- Implement an energy efficiency labelling system for buildings. In the near-term, establish a voluntary energy efficiency labelling system for commercial buildings, and award the first energy efficiency certificates.

[18] A Building Passport is a "whole life cycle repository of building information. It covers a building's administrative documentation as well as data regarding its plot and location, its technical and functional characteristics, and its environmental, social and financial performance" (GlobalABC and UNEP, 2021).

Promote the use of building passports

- Develop and maintain a system for regular information collection related to operation of building systems and energy use to improve availability and support access to building information for current and subsequent owners and those who work with the building.

Examples

- Smart Buildings in Indonesia: Building Energy Management Systems (BEMS) are being implemented with IT solutions - cloud computing and IoT - improving the energy performance and the occupants' comfort, in new and existing buildings. Policy support, tax incentives and awareness campaigns help the development of smart, green buildings in Indonesia, which could represent 20-25% of the country's building stock by 2025. For this reason, in 2018, JIExpo trade show was held in Jakarta, a fair organised to address the evolution of smart ways to use electricity, including "smart grids and metering, energy efficiency solutions, innovative lighting, building systems and automation, smart sensors and security" (PT Pamerindo Indonesia, 2018).

Tracking Progress

Potential indicators for tracking progress at a national scale may include:

- [SO.1.1] Presence of minimum energy efficiency standards for building systems (heating, cooling, ventilation and lighting), and appliances.
- [SO.1.2] Presence of mandatory labels with comprehensive information for consumers on energy performance of all appliance types.
- [SO.1.2] Proportion of/Number of products available that are compliant with MEPS.
- [SO.1.3] Amount spent on research and development for energy-efficient systems and appliances.
- [SO.1.4] Presence of local manufacturing of energy-efficient systems and appliances compliant with the minimum performance standards and labels.
- [SO.2.1] Presence of incentives for purchasing highly efficient systems by sector and system performance level.
- [SO.2.2] Proportion of/Sales volume of products with smart controls by system and appliance types and performance levels.
- [SO.2.3] Number of/Value of energy performance and service contracts.
- [SO.3.1] Value of building energy management systems services by sector based on surveys of sales and/or contract values.
- [SO.3.2] Proportion of/Number of energy audits carried annually by building type and sector compared to all related buildings.
- [SO.3.3] Value of recommissioning and maintenance contracts by sector.

- [SO.3.4] Presence of/Number of certified training programmes for building energy managers.
- [SO.3.4] Number of certified building energy managers.
- [SO.4.1] Presence of/Number of energy performance disclosure programmes.
- [SO.4.1] Proportion of/Number of buildings reporting energy under the performance disclosure programmes.
- [SO.4.2] Presence of requirements for building energy performance benchmarks by sector.
- [SO.4.3] Presence of digital data framework for reporting building energy performance.
- [SO.4.4] Presence of/Requirements for reporting on building passport information.
- [SO.4.4] Number of building passports issued per year.

Action Area 6: Sustainable energy

Introduction

The path to net zero-carbon emissions set out in the IEA report, Net Zero by 2050 is narrow and "requires immediate and massive deployment of all available clean and efficient energy technologies".(IEA, 2021b) Sustainable energy comprises energy from renewable and low-carbon energy sources, excluding traditional biomass and clean energy that is not a source of air or other pollution.

ASEAN has a target of 25% renewables supply and 25% of installed renewable electricity capacity by 2025. With buildings accounting for more than 27% of final energy consumption and CO_2 emissions in Asia, a transition to clean energy supply is critical to achieve energy access while mitigating CO_2 emissions in line with climate goals. Shifting to clean energy sources allows for reduced fossil fuel dependency, greater energy autonomy, reduced air pollution, reduced GHG emissions and provides local employment opportunities. Energy service companies (ESCOs) can help overcome upfront costs of renewable energies, accelerating their diffusion, while energy efficiency, demand response and energy storage can play important roles in enabling a greater penetration of variable renewables into the energy mix.

The shift towards providing buildings with low-carbon and renewable energy for essential energy services, such as cooking and lighting, is critical to meeting the Sustainable Development Goals and Paris Agreement goals. Achieving low-carbon energy integration in buildings implies phasing out the use of fossil fuels, especially oil and coal, for cooking, lighting and heating. However, it also means making use of low- and zero-carbon fuels wherever feasible, especially in electricity power generation. Assessing and maximising the use of on-site renewable energy resources and adopting building integrated renewables, such as solar PV and solar thermal, are effective means to reduce direct carbon emissions. Developing low-carbon and renewable-based district heating and cooling can enhance and optimise renewable energy use through sharing and mutualisation of local resources across a district. Increasing penetration of renewable energy in the electricity mix is also critical to limit indirect GHG emissions from buildings.

Vision for Sustainable Energy

Buildings have net zero-carbon operation and provide flexibility to the local sustainable and integrated energy system with the right policies and regulations in place.

Current context

ASEAN benefits from substantial renewable energy resources, including good solar irradiance, as well as hydropower potential, with multiple small-scale projects in the region, particularly in Indonesia, Malaysia, the Philippines, Thailand and Viet Nam. Besides this, Indonesia, Malaysia and Viet Nam host manufacturing industries for solar PV, wind and battery technologies. Renewable energy and low-carbon technologies (e.g. heat pumps) still face important challenges related to relatively high upfront costs and access to finance, the lack of supporting policies and regulations, site availability for renewable systems and low-energy prices affecting cost competitiveness and discouraging investments.

Market competitiveness of low-carbon energy technologies is still a challenge. Both economic incentives (e.g. investment grants, loan schemes, tax reliefs, remuneration of PV output, possibly allocated through competitive tenders) and regulations (mandates and building codes) can play a significant role in boosting deployment of renewable and low-carbon energy technologies in the buildings sector. Technologies that can benefit from such support include for instance solar thermal systems (e.g. for hot water), distributed solar PV systems, air-sourced and geothermal heat pumps, direct geothermal heat and renewable-based district heating and cooling.

Another key issue to tackle is the limited space availability for renewable energy systems in dense urban centres. Singapore has started the solar-ready roof programme where all new residential blocks with more than 400 m^2 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 to the grid. The total electrification across ASEAN overall stands at 96%; while for rural electrification it stands at 92.9%. However, rural rates vary across ASEAN: Myanmar at 57%, Cambodia at 90%, the Philippines at 94%, etc. Energy access and energy security remain a policy priority for Asian policy makers. However, those goals are currently pursued mainly through fossil fuel power sources, such as coal. The share of coal in Southeast Asia's power mix is expected to increase the fastest in the world due to new investments in new coal-fired power plants (IEA, 2019a) Given the long life of such assets, this could compromise climate objectives, or pose a financial risk of future stranded assets.

More than 208 million people in ASEAN do not have access to clean cooking facilities, yet achieving SDG 7.1 implies reaching 100% access to clean cooking by 2030 (UN ESCAP 2021).

Current status of policies for sustainable energy in buildings

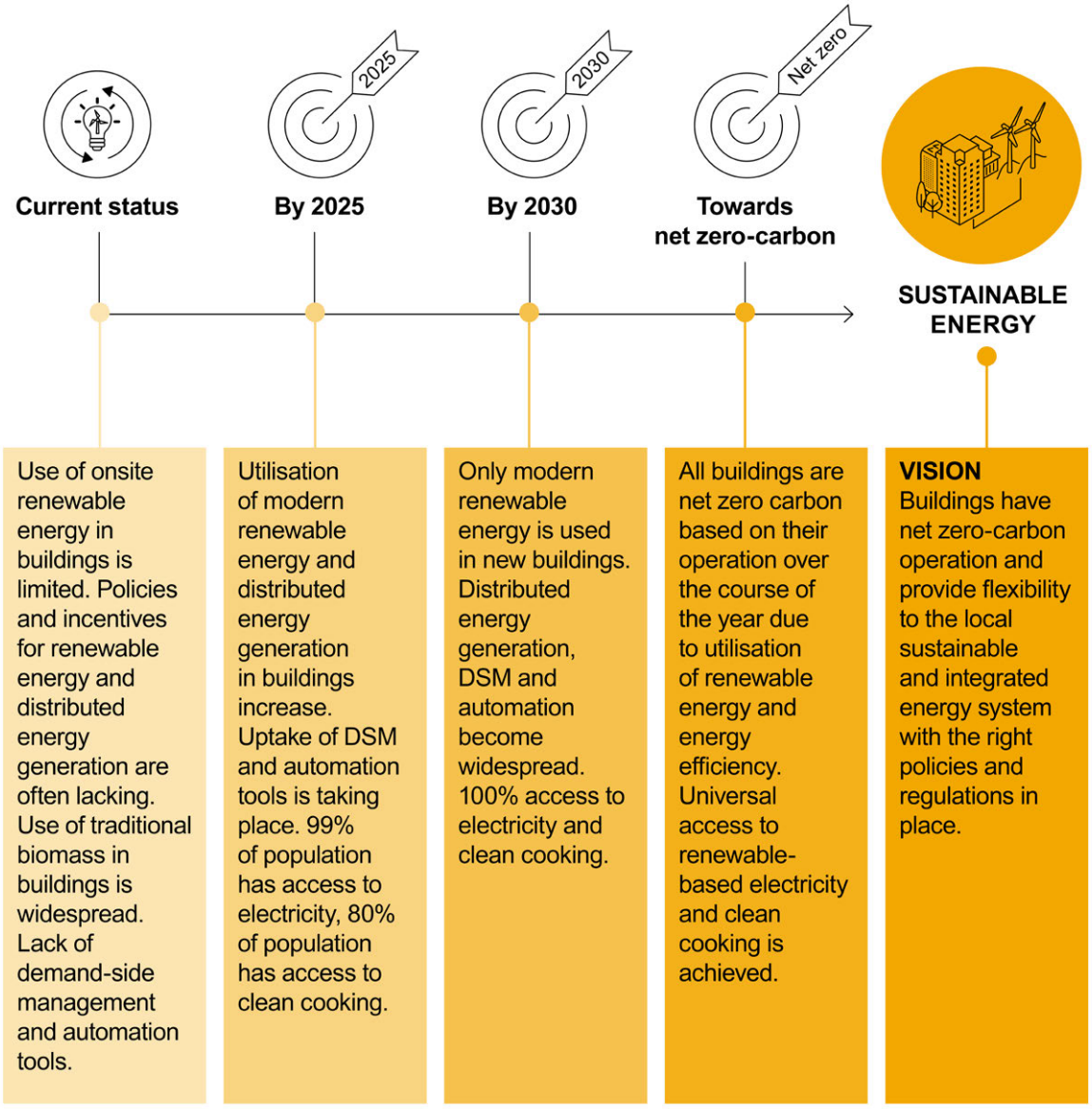
Country	Clean energy access policies	Building RE policies	Building grid flexibility policies
Brunei Darussalam			The PV Net Metering Programme approved by the government allows residential and commercial electricity from PV to sell excess electricity back to the national grid. Customers receive credits to offset their electricity bills
Cambodia	National Policy on Rural Electrification by Renewable Energy (2011) facilitates access to clean and renewable energy in the rural environment	Electricity Authority of Cambodia (EAC) regulation (2003) regulates the installation and connection of solar energy projects to the national power grid	
Indonesia	MEMR Regulation n. 13/2019 (in force): Operating licence exemption for small-scale rooftop photovoltaic power generation MEMR Reg. No. 50/2017 and MEMR Reg No. 53/2018 - Build, Own, Operate and Transfer scheme for renewable energy	MEMR Regulation n. 16/2021 The usage of rooftop solar PV is regulated. Specifies the main standards and processes for national producer Perusahaan Listrik Negara consumers installing rooftop PV	Sustainable Energy for Remote Indonesian Grids (SERIG) project (2016) aims to help small and remote grids deploy renewable energy more quickly
Lao PDR	Renewable Energy Development Strategy (2011- 2025) covers new renewable energy resources	Renewable Energy Development Strategy (2011-2025) promotes building integrated solar PV and off-grid hybrid systems	
Malaysia	Malaysian Green Technology Master Plan (GTMP) Feed-in Tariff	Malaysia – MS2680 – Energy Efficiency and Use of Renewable Energy for Residential Buildings Code of Practice	Net Energy Metering Guideline and Self-consumption Guideline for solar PV systems
Myanmar	National Energy Policy (NEP) covers building energy requirements and proposed incentives to implement green technologies and policies for the development of clean energy for a low-carbon economy		

Country	Clean energy access policies	Building RE policies	Building grid flexibility policies
Philippines	The Philippines Renewable Energy Act (2008) covers development and advancement of renewable energy resources, and the development of a strategic programme to increase its utilisation		
Singapore		SolarNova programme to aggregate demand for solar PV across public housing and government agencies. Adoption of renewable energy is encouraged through GM 2021 scheme	
Thailand	Clean Energy Access policy: Alternative Energy Development Plan 2015 – to include RE in the energy mix at 30% by 2037.	Solar Rooftop for Residential buildings (not more than 10kWp per household, 2.2 Baht (c.USD 70.4) per kWh for 10 years).	ERC Sandbox (Consideration of peer-to-peer energy trading, net metering, net billing, supply and load aggregator).
Viet Nam	Law on Economical and Efficient Use of Energy promotes renewable and clean energy at urban development scale and households. Million Green Homes is promoting solar PV and energy efficiency technologies to a million houses or buildings by 2030.	Feed-in tariff for roof- top solar and biomass CHP. Direct corporate RE procurement being piloted soon.	
ASEAN			

Note: Blank areas of the table indicate that no relevant information was found during data collection.

Summary of strategy for sustainable energy

Summary of milestones for Sustainable Energy towards net zero-carbon



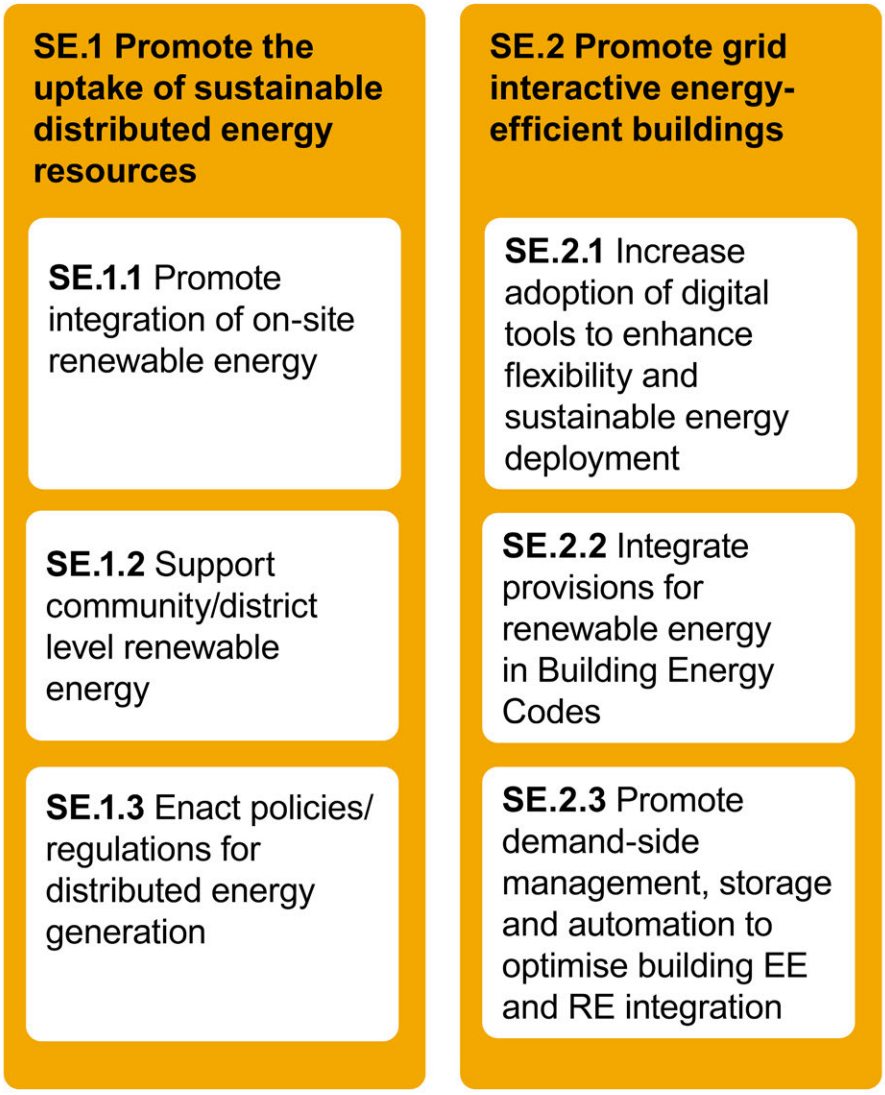
Note: The modern renewable energy share includes various types of renewables (i.e., biomass, geothermal, solar, hydro, wind and biofuels), but excludes traditional biomass, which typically involves combustion of biomass in the form of wood, animal waste and traditional charcoal. These are usually harvested and used in an unsustainable and unsafe way.

The Roadmap's strategy for advancing the integration of sustainable energy in buildings in ASEAN includes two key actions in the area of Sustainable Energy (SE):

1. Promote the uptake of sustainable distributed energy resources.
2. Promote grid-interactive energy-efficient buildings.

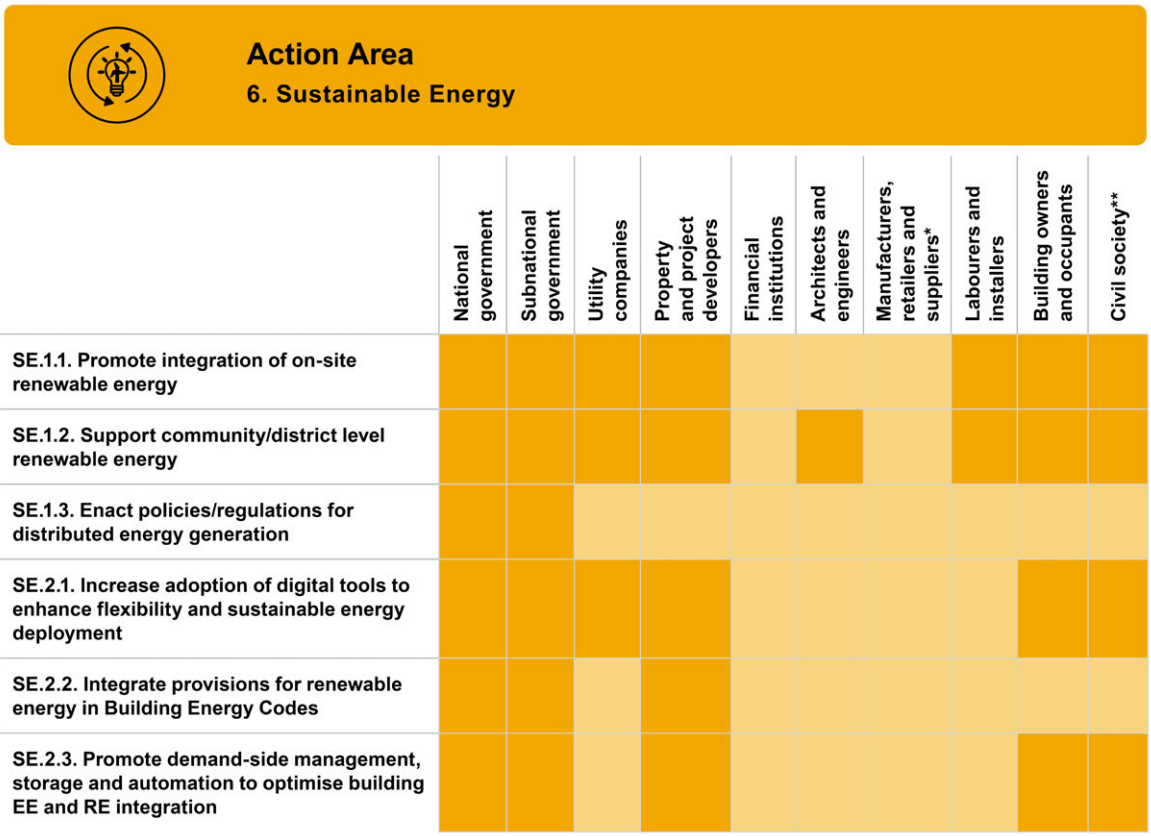
Within these Actions, the Roadmap suggests six Activities (e.g. SE.1.1, SE.2.2, etc.) related to sustainable energy.

Summary of Roadmap strategy for Sustainable Energy



As multi-stakeholder collaboration is one of the overarching principles of this Roadmap, it is important to consider which stakeholder groups could be involved in the delivery of each activity. Various stakeholder groups should be involved in the activities under the Sustainable Energy action area in order ensure their effective implementation.

Stakeholder mapping for Sustainable Energy



*of appliances and materials. Includes product testers and certifiers.

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

Note: The darker the colour, the higher the importance of that stakeholder group for the activity and the more essential the group is for the activity's effective implementation.

Actions, Activities and Timelines

SE.1: Promote the uptake of sustainable distributed energy resources

SE.1.1. Promote integration of on-site renewable energy	**Current status:** The AMS vary in terms of policies promoting onsite renewable energy for buildings, with only several having adopted the mandates to promote renewable readiness or incentives. A small share of buildings across the region has on-site renewable energy systems. Traditional biomass is still widely used, especially for cooking in rural areas and informal settlements/slums.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Renewable energy programmes for new buildings are initiated and demand for renewable energy systems for existing buildings is supported through incentive programmes and regulation. All public buildings are targeted by these programmes. Programmes to enhance access to clean cooking through energy efficiency and renewable energy generation are introduced for informal settlements/slums and rural areas.	Expand renewable energy programmes for 50% of new and 25% of existing buildings to benefit from a combination of energy efficiency measures and on-site renewable energy systems. 100% access to clean fuels for cooking and programmes for delivering more efficient and renewable energy-based appliances to all low-income households are implemented.	All buildings have energy efficiency measures and on-site renewable energy solutions. Universal access to clean and affordable renewable energy-based and efficient cooking is achieved in the region.
SE.1.2. Support community/district-level renewable energy	**Current status:** Some jurisdictions promote district-level renewable energy schemes for new developments. Existing communities have few mechanisms for supporting district/community renewable energy schemes.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Guidelines for feasibility assessment, development and implementation of district cooling systems with integration of renewable energy are developed. Assessments are conducted for several districts in several AMS to evaluate the feasibility of renewable energy-based district cooling projects. Policy incentives for RE community projects, micro-grids	Renewable district cooling initiatives are implemented through urban planning measures in several new developments in different AMS, which show high feasibility for renewable energy-based district cooling based on the assessments.	All new developments with high density and substantial energy needs identified in the feasibility studies have implemented renewable energy-based district cooling systems.

	and renewable energy-based district cooling networks are implemented in several jurisdictions.		
SE.1.3. Enact policies/regulations for distributed energy generation	**Current status:** Few AMS have policy frameworks in place to support distributed energy generation		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	All AMS have adopted detailed regulatory frameworks to support distributed energy generation and grid flexibility solutions, and to support building integrated renewable energy development.	All AMS have tested developed regulatory frameworks and made adjustments where necessary. Incentives for the implementation of distributed energy generation and grid flexibility solutions are introduced. Regular audits and updates of regulations and incentives take place to take into consideration evolving contexts (costs of technologies, renewable energy-readiness of the building stock, roll-out of smart meters, etc.).	Distributed energy generation, grid flexibility solutions and building integrated renewable energy projects are widely implemented, supported by the developed regularly updated policy frameworks that allow for self-consumption and sale of excess renewable energy to the grid, peer-to-peer trading, etc. Most incentives are no longer needed as distributed energy generation becomes a well-integrated part of the energy market in ASEAN.

Near-term recommendations to support the uptake of sustainable distributed energy resources

Promote integration of on-site renewable energy

- Accelerate the adoption of decentralised renewable energy systems, such as PV, building integrated PV, solar thermal, heat pumps, direct use of geothermal, biogas and energy storage projects (e.g. thermal and electric storage) in the planning and design of buildings and neighbourhoods.
- Promote efficient and renewable energy-based cooking solutions among vulnerable groups of the population (low-income households living in slums and rural areas) in order to phase out use of traditional biomass.
- Develop policy frameworks for investment and finance. This framework is critical to mobilise green financing frameworks including green bonds to catalyse private investments in green buildings. "In ASEAN, the number of green bonds issued to fund green building projects is projected to increase (CBI, 2018). Green buildings are recognised as a legitimate project that may be financed through green bonds under the International Capital Market Association Green Bond Principles and the ASEAN Green Bond Standards" (Kapoor et al., 2020).

Support community/district-level renewable energy

- Enable a systemic approach through integrated planning (including heat-mapping, prospective demand assessment for energy needs, zoning, etc.) of renewable energy development at the district level to deliver more efficient and low-carbon solutions. Exploit cross sectoral synergies (for example by waste heat recovery from industries in the neighbourhood).
- Develop a feasibility assessment framework for district-level renewable energy and district cooling projects and encourage local governments to use it to identify potential development projects.

Enact policies/regulations for distributed energy generation

- District renewable energy planning. Enable a systemic approach through integrated district renewable energy planning (including heat-mapping, prospective demand assessment for energy needs, zoning, etc.) to deliver more efficient and low-carbon solutions. Enact policies to exploit cross sectoral synergies (waste heat recovery from industries in the neighbourhood, etc.).
- 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 the establishment of net metering or peer-to-peer energy trading helps to spur distributed renewable energy investments. Such investments would be used with a clear timeline of their applicability. Stop/go policies and retroactive changes must be avoided in order not to reduce investor confidence, disrupt chains and compromise the financial stability of an emerging supply chain and small actors.
- Continue phasing out fossil fuel subsidies while supporting the most vulnerable people and groups' transition to renewable energy sources. This will improve the cost competitiveness of renewable energy versus fossil fuels, and boost the efficiency of other renewable energy incentives.
- Create a carbon tax or renewable energy certificate marketplace.
- In cases where local distributed generation is not sufficient to meet the local energy demand, buildings and neighbourhoods can buy low-carbon energy from the grid through power purchase agreements (PPAs). Depending on the country's power sector structure, some regulatory changes might be needed to allow for such procurement to take place.

Examples

- Malaysia's investment targets for renewable energy: Malaysia will seek investment of RM 33 billion (approximately USD 8 billion) 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, currently only 2% comes from renewable energy sources.

- Singapore's plans for solar installations: To overcome Singapore's land constraints, the government through the tenders administered by the Housing Board (HDB) has been aggregating and maximising solar installations on public-sector buildings under the SolarNova Programme. By 2021, HDB "committed a total solar capacity of 380 MWp for about 8,400 HDB blocks". Singapore has also set a new national 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 and innovative spaces such as reservoirs, offshore and building facades.
- Indonesia to invest more in solar energy: To achieve the 23% target of renewable energy in the energy mix by 2025, the Government of Indonesia promotes the installation of solar rooftop PV. The government aims to increase the installed capacity to 2.14 GW by 2030, "focusing on the buildings and facilities of state-owned enterprises (742 MW), industries and businesses (624.2 MW), households (648.7 MW), consumers of state electricity company PLN and social groups (6.8 MW), and government buildings (42.9 MW)" (Indonesia Ministry of Energy and Mineral Resources, 2021)

SE.2: Promote grid-interactive energy-efficient buildings

SE.2.1. Increase adoption of digital tools to enhance flexibility and sustainable energy deployment	**Current status:** Limited availability of digital planning and deployment tools for renewable energy across the AMS.		
	By 2025:	**By 2030:**	**Towards net zero- carbon**
	Regional open access data framework is developed for evaluating building-integrated RE potential, including geospatial and climatic data analysis and technology databases. Open standards for renewable energy supply-demand management are developed.	Online and mobile tools for estimating building integrated renewable energy availability and opportunities are developed. A register of certified renewable energy products and installers is established. Mandatory open standards for digital integration of demand management of renewable energy with suppliers are adopted.	Digital demand management systems for buildings are made mandatory to monitor energy consumption and renewable energy generation and enable efficient interaction between energy consumers, prosumers and the grid, as well as peer-to-peer energy trading.
SE.2.2. Integrate provisions for renewable energy in Building Energy Codes (BECs)	**Current status:** Few AMS have requirements for renewable energy integration into their BECs.		
	By 2025:	**By 2030:**	**Towards net zero- carbon**
	National roadmaps with targets and recommendations for renewable energy integration into BEC for new buildings are developed.	Several AMS have incorporated requirements for renewable energy integration into their BECs.	All AMS have incorporated requirements for renewable energy integration into their BECs.

SE.2.3. Promote demand-side management (DSM), storage and automation to optimise building energy efficiency and renewable energy integration	**Current status:** Integration of onsite DSM protocols, storage and requirements for building energy management and automation are largely lacking in building policies or codes.		
	By 2025:	**By 2030:**	**Towards net zero- carbon**
	National frameworks setting out guidance for DSM, storage, building energy management and automation requirements for new and existing buildings.	Mandatory requirements for DSM, storage and building energy management and automation are adopted for all new large or energy-intense non-residential buildings in the region.	Mandatory requirements for DSM, storage and building energy management and automation are adopted for all buildings in the region.

Near-term recommendations to support grid-interactive efficiency buildings

Increase adoption of digital tools to enhance flexibility and sustainable energy deployment

- Develop regional open access data frameworks for evaluating building integrated renewable energy potential, including geospatial and climatic data analysis and technology databases.

Integrate provisions for renewable and sustainable energy in Building Energy Codes

- 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 energy codes. The codes could be developed jointly among national authorities, builders and other stakeholders. Hence, appropriate technologies are considered and mandatory requirements are applicable, enforceable and well-designed. Building codes could also include requirements in structural integrity or other requirements which will enable the safe inclusion of on-site renewable energy systems.

Promote demand-side management, storage and automation to optimise building efficiency and renewable energy integration

- Update regulatory frameworks and incorporate renewables in utility planning. The countries of Asia have varying degrees of liberalisation and decentralisation of their electric power industries. For the AMS with centrally planned energy sector structures, a regulatory enforcement of and resource allocation for renewable energy integration are needed. For those with more liberalised markets, updates

of the existing regulatory framework to incentivise utility-scale and distributed renewable energy developers to make such projects more completive would be necessary.

Tracking Progress

Indicators are an important tool for understanding the changes in conditions that affect whether progress towards a target of net zero-carbon buildings and construction is being made.

For sustainable energy, indicators that track policies that seek to improve sustainable (i.e. clean and renewable) energy access to clean fuel use in household activities of cooking and hot water heating are important. Additionally, actions that introduce regulations around building code requirements for renewable energy, and the building of integrated storage systems where appropriate are needed to understand whether the fuels used are helping to increase the stock of zero-carbon buildings.

Potential indicators for tracking progress include:

- [SE.1.1] Presence of requirements for on-site renewable energy in green building certifications, adopted in stretch codes and in regulations.
- [SE.1.1] Amount of installed capacity of on-site renewable energy by building type.
- [SE.1.1] Installed capacity of building integrated thermal and electric storage.
- [SE 1.1] Proportion of population having access to clean and renewable energy for cooking and household activities.
- [SE.1.2] Presence of requirements for community and district-level renewable energy in certifications, adopted in stretch codes and in regulations.
- [SE.1.2] Amount of installed capacity of community and district-level renewable energy.
- [SE.1.3] Presence of policies and regulations for requirements on on-site distributed renewable energy generation.
- [SE.2.1] Proportion of/Number of digital smart meters and/or demand management systems installed in buildings compared to all meters.
- [SE.2.2] Presence of requirements for renewable energy integration in buildings incorporated into building energy codes.
- [SE.2.3] Presence of requirements for DSM in building regulations.

Action Area 7: Resilience

Introduction

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 global disaster mortality; reducing the number of affected people; reducing economic and infrastructure losses; strengthening governance and local capacity to develop disaster risk reduction strategies, multihazard early-warning systems and disaster risk information, as well as enhancing international cooperation to developing countries (UNDRR, 2015).

Climate and climate change affect construction in two principal ways: 1) as the climate changes, buildings' and building materials' design standards may have to be adapted 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 may occur. Therefore, the objective is to use integrated approaches to upgrade the durability and resilience of all buildings by gradually addressing the most critical infrastructures (e.g. those with social, economic and environmental relevance, such as hospitals, emergency facilities, schools, power plants, hazardous material facilities), followed by the most vulnerable buildings and the rest of the building stock, (Hotchkiss and Dane, 2019) (NREL, 2018).

Vision for Resilience

Buildings are designed to be resilient to climate change risks and extreme weather events, protecting vulnerable populations, with resilience attributes integrated into building design and materials.

Current context

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 not only because such disasters have been more frequent, but also because the value of public and private assets located in vulnerable locations has increased (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 (UN Habitat and UN ESCAP, 2015). Because of "the concentration of human activities in urban areas, 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 ten times higher" (ADB, 2017). Asian cities are largely underprepared for natural disaster risks, especially with respect to vulnerability and risk assessment practices. Comprehensive hazard assessment and mapping are not uniformly employed. This 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 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.

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, have national plans for climate change resilience. This does not always include the buildings sector.

Energy efficiency and decarbonisation actions help improve the resilience of buildings against changing climate by reducing heat gains and by providing adaptive capacity against heat waves.

Current status of policies for resilient buildings

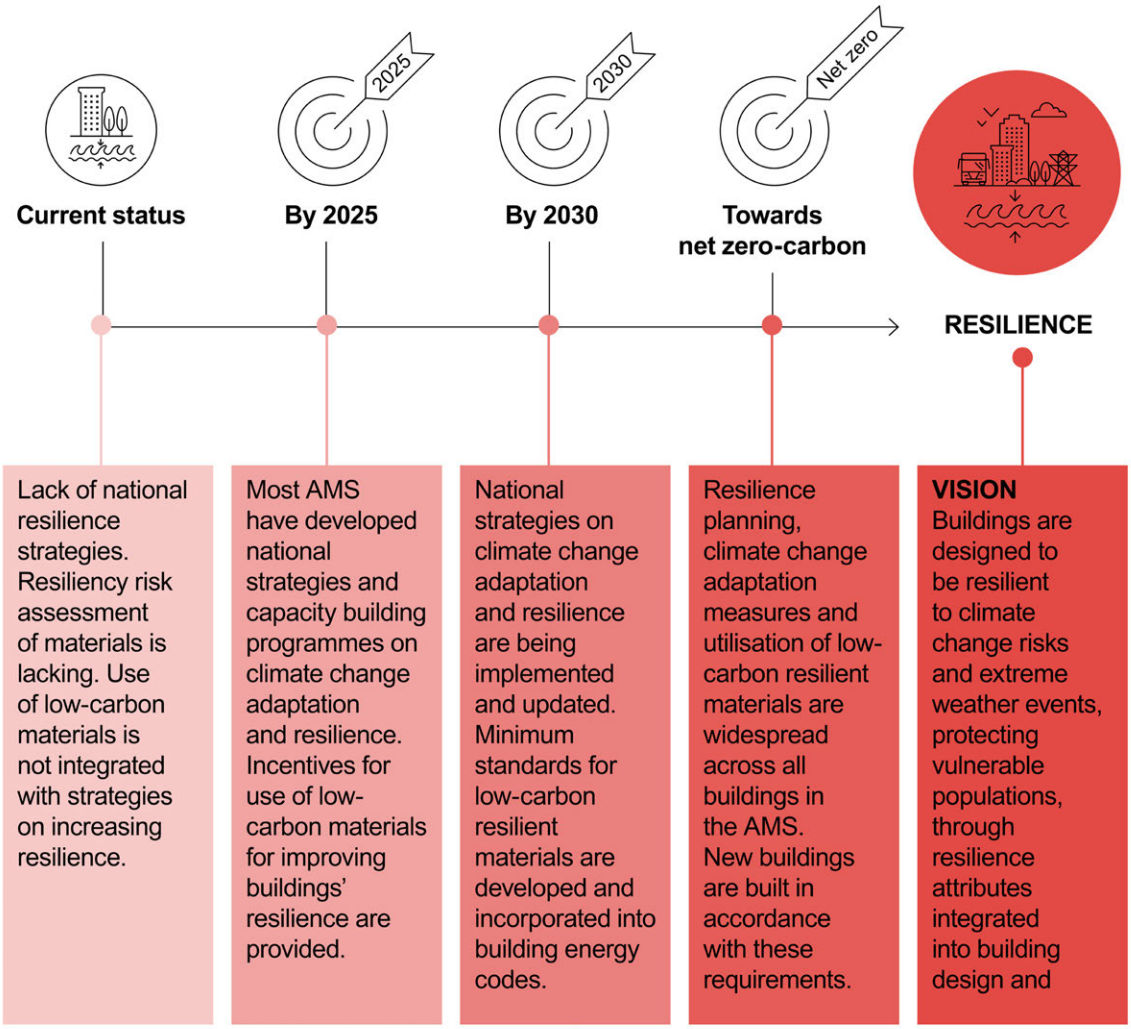
Country	Adaptation plans	Resiliency in building codes	Other
Brunei Darussalam	Brunei National Climate Change Policy (2020) covers reducing GHG emissions through industrial emissions including renewable energy, power management and carbon pricing		
Cambodia	Cambodia National Adaptation Plan - Financing Framework and Implementation Plan aims to decrease vulnerability and incorporate climate change adaptation		
Indonesia			

Country	Adaptation plans	Resiliency in building codes	Other
Lao PDR			
Malaysia			
Myanmar	National Adaptation Plan of Action (NAPA), 2012; 2018-2030); Indicates the importance of 'climate-proof' infrastructure, including "weather-proof buildings (particularly schools and hospitals)"	Climate Change Action Plan for the Urban Sector Guidelines on Climate Change-Resilient Architecture in Myanmar MNBC (Myanmar National Building Code) 2020	Myanmar Action Plan on Disaster Risk Reduction 2017 and Myanmar Sustainable Development Plan (2018-2030)
Philippines			
Singapore	Sustainable Singapore Blueprint (2015) outlines the national vision and plans for a more liveable and sustainable Singapore through resource sustainability and air quality		GM2021 Resilience Section within Green Mark evaluates buildings on their climate mitigation and adaptation strategies and encourages the use of nature-based solutions and a greater approach to circularity
Thailand	Climate Change Master Plan (2015 – 2050)	Climate Change Master Plan: Strategy 2 Mitigation and low-carbon development	
Viet Nam			
ASEAN			

Notes: Blank areas of the table indicate that no relevant information was found during data collection.

Summary of strategy for resilience

Summary of milestones for Resilience towards net zero-carbon

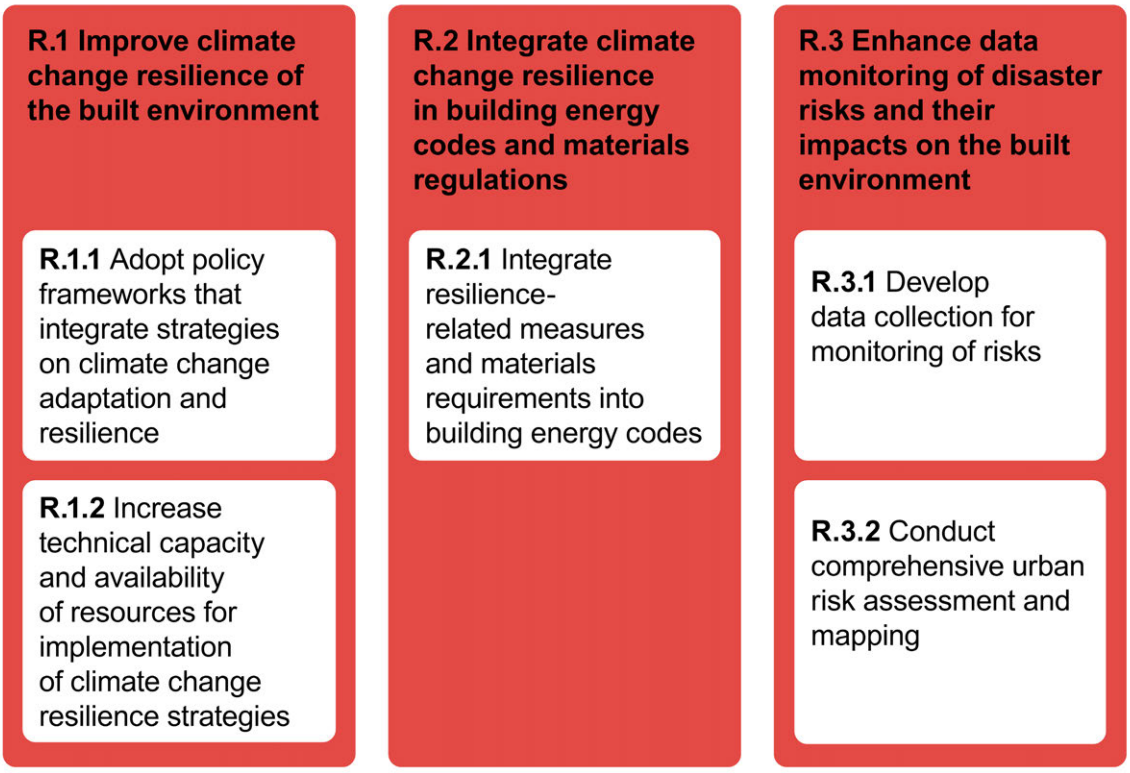


The Roadmap's strategy for increasing the resilience of buildings in ASEAN includes three key actions in the area of Resilience (R):

1. Improve climate change resilience of the built environment.
2. Integrate climate change resilience in building energy codes and materials regulations.
3. Enhance data monitoring of disaster risks and their impacts on the built environment.

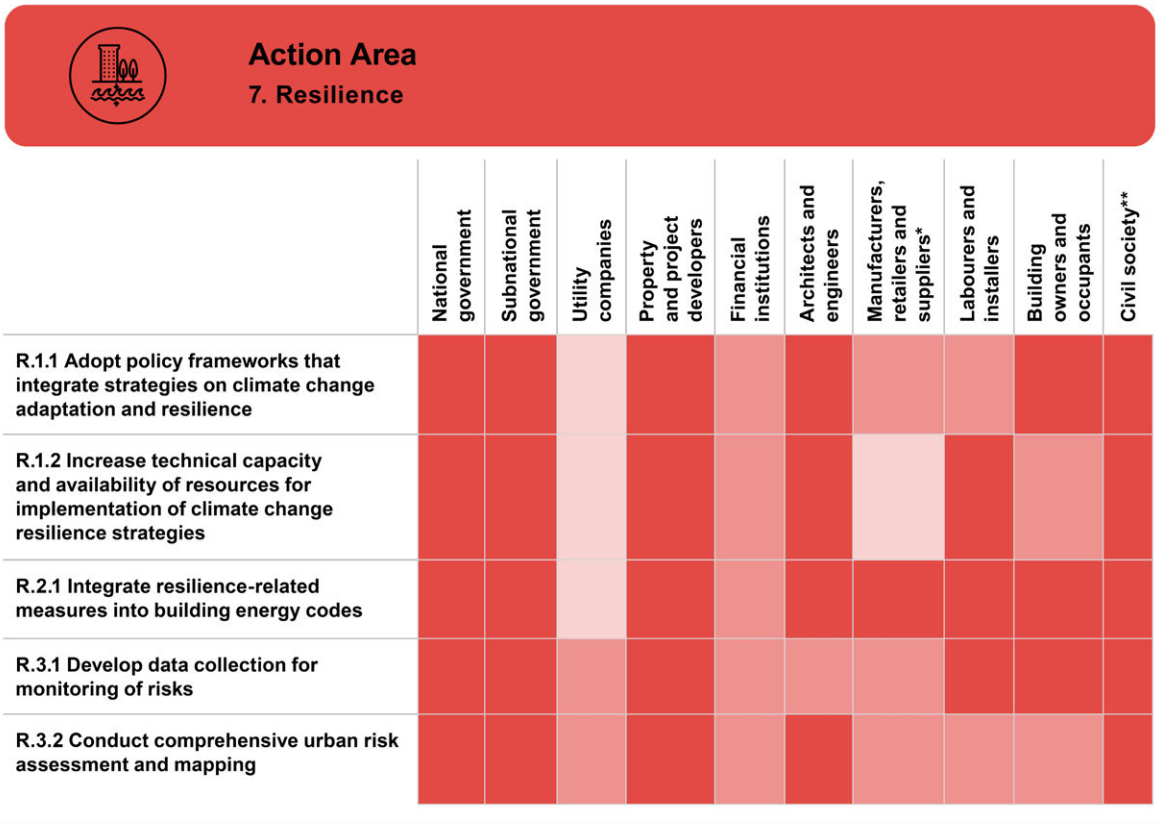
Within these Actions the Roadmap suggests five Activities (e.g. R.1.1, R.2.2, etc.) related to Resilience.

Summary of Roadmap strategy for Resilience



As multi-stakeholder collaboration is one of the overarching principles of this Roadmap, it is important to consider which stakeholder groups could be involved in the delivery of each activity. Various stakeholder groups should be involved in the activities under the Resilience action area in order to ensure their effective implementation.

Stakeholder mapping for Resilience



*of appliances and materials. Includes product testers and certifiers. ** including academia, non-governmental organisations, research institutions, social networks and community associations.

Note: The darker the colour, the higher the importance of that stakeholder group for the activity and the more essential the group is for the activity's effective implementation.

Actions, activities and timelines

R.1: Improve climate change resilience of the built environment

R.1.1 Adopt policy frameworks that integrate strategies on climate change adaptation and resilience	**Current status:** Few national resilience strategies currently exist in the AMS. There are only a few city-level resilience strategies.

R.1.2. Increase technical capacity and availability of resources for implementation of climate change resilience strategies	**Current status:** Current institutional capacity in supporting resilience in building development and urban adaptation is available with the national and local governments.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Capacity building programmes on climate change adaptation strategies and resilience are provided to local governments.	All high-risk subnational and local jurisdictions have held capacity building training sessions on climate change adaptation strategies and resilience, and have allocated resources for their implementation.	All subnational and local jurisdictions have held capacity building training sessions on climate change adaptation strategies and resilience. Subnational and local governments in the AMS regularly allocate resources and access external sources of finance for related project development and implementation.

Near-term recommendations to support improvement of climate change resilience of the built environment

Adopt policy frameworks that integrate efficient and effective strategies on climate change resilience

- Develop a national strategy on climate change adaptation that identifies the list of policies and measures that can support increased resilience of buildings in an integrated manner and addresses the potential for relocation and crisis plans for high-risk settlements. It is important to develop resilience strategies at the national, subnational and local levels that would include planning for critical infrastructure (hospitals, schools, water supply, energy supply, etc.), as well as the requirements for "building back better" during reconstruction after a disaster with integration of sustainable energy measures in order to avoid locking in energy savings.
- Work across governments and stakeholders to develop assessment plans that help to ensure that resilience strategies are aligned across jurisdictions and agencies.
- Use data and information to document potential risk exposure by location to enable effective urban planning through appropriate land-use strategies, regulations, and risk-sensitive investments 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.

Increase technical capacity and availability of resources for implementation of climate change resilience strategies

- Provide training to national, subnational and local governmental officials about assessing climate risks, developing vulnerability maps and establishing multi-stakeholder collaborations on the development of integrated policies to enhance resilience of the built environment.
- Provide training on the communication of risks and benefits associated with improved resilience. This will require data collection and analysis to enable the creation of databases, resource platforms and information campaigns.

Examples

- **Resilient Da Nang**: 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 2016, 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 flood plains or frequently affected by flood"; 6) ''develop the model of a flood-resilient community'', and 7) "develop monitoring and early-warning systems for flood risk" (100 Resilient Cities, 2017).
- **Co-ordinating resilience planning in the Bangkok Metropolitan Region:** Bangkok, the capital of Thailand, supporting over 8 million people in the city and over 14 million in its metropolitan area, is highly exposed and vulnerable to floods caused by seasonal storms. 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 with "soft" instruments at the metropolitan scale. For example, "Bangkok's Comprehensive Plan 2014-2018 provides tools that can be used 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 only been adopted by the Bangkok Metropolitan Authority, and all local governments in the Bangkok Metropolitan Region should be using them", whereas these tools could benefit the metropolitan region as a whole (OECD, 2018).

R.2: Integrate climate change resilience in building energy codes and materials regulations

R.2.1. Integrate resilience-related measures into building energy codes	**Current status:** Resiliency risk assessment of materials in the AMS is limited overall, and generally lacking for low-carbon materials. Minimal resilience measures are incorporated into building energy codes (BECs).		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	Roadmap for integrating resilience measures and materials requirements into BECs is developed.	Minimum standards for low-carbon resilient materials are developed and incorporated into BECs alongside other resilience-related measures targeting new buildings.	All AMS have updated their BECs to incorporate minimum standards for low-carbon resilient materials alongside other resilience-related measures targeting new buildings and existing buildings undergoing major renovation.

Near-term recommendations to support integration of climate change resilience in building codes and materials regulations

Integrate resilience-related measures and materials into building energy codes

- Incorporate measures into BECs 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 into BECs within the next decade to ensure that new 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.

R.3: Enhance data monitoring of disaster risks and their impacts on the built environment

R.3.1. Develop data collection for monitoring of risks	**Current status:** Minimal data collection and monitoring of disaster risks and extreme events. Lack of assessments of risks of natural disasters and extreme events on buildings.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	About half of AMS jurisdictions monitor disaster risks and extreme events. Early-warning systems are implemented in most vulnerable areas.	All AMS jurisdictions monitor disaster risks and extreme events. Comprehensive data and monitoring systems are available and provide necessary data to develop mitigation strategies for buildings.	Comprehensive data collection and monitoring of risks and events are implemented in AMS all jurisdictions. Mitigation strategies for buildings to cope with disaster risks and extreme events in a sustainable manner are developed.
R.3.2. Conduct comprehensive urban risk assessment and mapping	**Current status:** Few AMS have mapped risks and vulnerability of population, including risks to critical infrastructure and informal settlements in risk-prone areas.		
	By 2025:	**By 2030:**	**Towards net zero-carbon**
	All AMS have implemented basic national risk and vulnerability mapping.	All subnational and local jurisdictions have implemented basic risk and vulnerability mapping.	All AMS, subnational and local jurisdictions have implemented enhanced analysis and visualisation of risk and vulnerability mapping.

Near-term recommendations to support data monitoring of disaster risks and extreme events and their impacts on the built environment

- **Data and monitoring**. 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 can prepare upgrading and resilience plans by widening roads, installing flood protection and building new infrastructure.
- **Social networks**. 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 residents and neighbours form close relationships, they can better understand and respond to the changing needs of the most vulnerable people in their community, notably the elderly and children.

Examples

- **Hat Yai City Resilience:** The Hat Yai city in Thailand is one of the participants in The Asian Cities Climate Change Resilience Network - a participatory community planning project which aims to catalyse actions for building the climate change resilience of vulnerable cities in Asia. As Hat Yai is one of the cities most affected by floods in the country, a co-operation project was implemented in the city aiming to integrate the government, civil society and communities in flood management based on an integration policy. An innovation as part of the information dissemination was the use of media as a significant factor to create public awareness and to facilitate co-operation between the public and private sectors. The Hat Yai Asian Cities Climate Change Resilience Network experience served as the basis for studies launched in Songkhla province, Thailand in 2018 to observe the success factors of public policies in disaster management and to draw up sustainable guidelines.
- Building resilience against climate related hazards: The municipality of Pakokku, Myanmar, suffers from extreme flooding of the Ayeyarwady River and severe erosion. Cordaid, in partnership with Karuna Mission Social Solidarity, is implementing a disaster risk reduction programme. The goal is to build community resilience against extreme weather-related events. The work involves communities and local actors to systematically manage disaster risks in order for the region to become safer and more resilient. The approach is based on six main activities: (1) capacity building training; (2) disaster risk assessment and analysis; (3) community action planning, through Contingency and Development Plans; (4) creation of working groups/committees; (5) implementation of Disaster Risk Reduction measures; and (6) monitoring, evaluation and learning. A Community Action Plan with the communities was developed for each village, presented to the municipal government and, after its approval, the implementation of the measures was organised with the support of all residents. In addition, the municipal government has been intensively involved, participating in training on Disaster Management Systems and Early Warning. The Department of Meteorology and Hydrology also installed water meters in all project villages.

Tracking Progress

Potential indicators for tracking progress include:

- [R.1.1] Presence of policy frameworks and strategies on climate change adaptation and resilience.
- [R.1.2] Presence of guidelines and training courses for adaptation planning for development professionals.
- [R.2.1] Number of local governmental officials who have taken the training courses.
- [R.2.1] Presence of requirements for climate-resilient materials in green building certifications, adopted in stretch codes and in regulations.

- [R.3.1] Presence of data frameworks for reporting building climate risks and impacts.
- [R.3.2] Presence of standards for risk mapping and risk assessments for building constructions.
- [R.3.2] Presence of comprehensive climate sensitive risk mapping for cities and municipalities.
- [R.3.2] Proportion of / Number of municipalities undertaking regular and comprehensive climate risk assessments.

Conclusions and the way forward

After industry, the buildings sector is the second-largest energy consumer in ASEAN, accounting for 28% of total final energy consumption (IEA, 2020c). Improving energy efficiency and increasing the share of renewable energy utilisation in buildings operation reduce energy and carbon embodied inbuilding materials and equipment. Increased energy efficiency and renewable energy make buildings a key sector for achievement of the ASEAN targets to reduce energy intensity (by 30% by 2025 in relation to the 2005 levels), and increase the share of renewable energy in the total primary energy supply (to reach 23% by 2025).

This Roadmap has covered seven action areas and outlined actions crucial for achieving the net zero-carbon level of buildings' performance in ASEAN.

While the implementation process of the Roadmap can start from any area, according to the national priorities and available resources, the importance of a holistic approach cannot be underestimated – these activities and actions could be considered as elements of the integrated policy development to support transition of the buildings sector towards the net zero-carbon.

In order to identify a combination of these "ingredients" tailored to a country's unique context, the following steps can be taken to maximise the impacts of the Roadmap:

- **Contextual assessment**. It is important to start the process of the Roadmap's implementation with a context mapping of the country's buildings sector to establish a foundation for further policy development. Such a contextual assessment is based on the understanding of building energy demand depending on the climate, socio-economic factors, current technological and fuel mix used for various building energy end uses, behavioural patterns of buildings' users, etc. The assessment is also based on potential growth drivers, such as population growth, increasing access to energy (i.e. increasing number of energy users), income growth trends, urbanisation, trends in new construction and renovation. It is also important to include into the assessment the mapping of existing policies, commitments, programmes, projects, knowledge resources (publications, policy documents, training, etc.), and institutional establishments related to energy efficiency and renewable energy in buildings.
- **Planning and stakeholder engagement.** Under ideal circumstances, a country would embark on the journey of implementing all the actions outlined in all seven areas to accelerate its progress towards net zero-carbon as much as possible. In reality, however, this process is likely to be constrained by a variety of factors,

such as policy priorities, existing commitments, socio-economic context, availability of data, resources and capacity. ASEAN Member States (AMS) have different starting points depending on the status of their buildings sectors and the "gap" which has to be bridged to achieve net zero-carbon. Taking into account these aspects and building upon the results of the contextual assessment, a national government could identify priorities for its buildings sector and the scope for the Roadmap's implementation plan. It is important to involve various stakeholder groups in these processes and decisions regarding which areas and actions to start from. Each action area of the Roadmap provides an overview of the stakeholder groups and assessment of their importance for each action. The following steps can be taken in order to ensure effective stakeholder engagement:

- Identify a governmental entity that will be leading the process of the Roadmap's implementation.
- Establish a mechanism for multi-stakeholder engagement (e.g. cross-functional teams or thematic task forces, regular stakeholder consultations with adequate representation of a variety of stakeholders, online platforms for dialogues, provision of feedback and comments on proposals for action, etc.).
- Establish a dialogue with subnational and local governments to ensure alignment of policy priorities between different levels of governance and co-ordination of efforts.
- Set up open reporting and communication channels on the process (e.g. meeting reports, news articles, publications and updates on governmental websites) to engage a wider audience and document the progress.
- **Implementation plan**. Once the outline of actions and activities is established through a series of stakeholder consultations, it is important to consolidate this information into a coherent implementation plan with assigned roles to and responsibilities for different institutions for implementation of each action.
- It is important for a country to implement the actions in a way that builds upon local context, institutional structures and policy frameworks (as reviewed during the context assessment) and paves the way in a holistic manner for future measures and pathways towards a sustainable buildings sector.
- In order to identify priority actions and establish an implementation timeline for each of them, a country may consider the following guiding criteria (adapted from [Cool Coalition, 2021]):
- **Level of effort.** This entails the level of effort anticipated to implement the action: the lower the level of effort, the sooner the implementation can be completed. It is important to consider challenges and enablers in the evaluation of the level of effort. The evaluated level of effort may also be used to determine the timeline of the implementation of each action.
- **Expected Impact.** This requires the evaluation of the benefits and impacts of each action in terms of bringing the buildings sector closer towards the net zero-carbon. Expected energy savings, embodied energy and emissions reductions over buildings' lifetimes, as well as socio-economic benefits and the contributions to the

achievement of other national policies and international commitments, could be considered.

- **Resource Requirements**. Evaluation (even if an approximate one) of required resources (in terms of time, finances, human and technical capacity) and its comparison to the current availability of the resources in the country is needed in order to identify potential barriers and delays for the implementation. When calculating the costs it is important to take into account the cost requirements and savings over the action's lifetime and not only the upfront cost of implementation.

An implementation plan could incorporate a strategy for tracking progress across selected actions. Each action area of this Roadmap provides suggestions for high-level indicators for each activity. In the Implementation plan it is important to identify detailed indicators specific to each action that will enable data to be collected and analysed in order to evaluate the success of the implementation.

In order to accelerate the progress along the net zero-carbon pathway for the buildings sector, a comprehensive policy package is an essential cornerstone of the implementation plan.

The following recommendations of the Roadmap are not prescriptive, but highlight the most important actions that need to be taken on the way towards net zero-carbon buildings. These are:

- **Performance-based building energy codes** are regulations that set minimum requirements for various parameters that may include building fabric and system performance levels, as well as the whole building's performance, which is required to increase over time. It is important that building energy codes also integrate renewable energy and resilience-related measures. Such regulations are crucial to reflect a government's commitment to low-carbon and efficient buildings and to send a clear signal to industry, investors, owners and occupants, which makes clear the support for market transformation.
- **Certification and labelling programmes** set standards for buildings and systems and provide identification labels to show that certification has been achieved. Applying these to new buildings and systems along with major renovations increases consumer confidence and performance compliance.
- **Renewable energy**, whether on-site or district-level, provides a direct source of zero-carbon energy to reduce building-related CO_2 emissions. Policies for distributed renewable energy generation and demand-side management with automation tools will support renewable energy projects and enhance the flexibility of buildings' interactions with the grid.
- **Incentives** that encourage energy efficiency performance improvements and low-carbon solutions are often needed to prompt actions. Non-financial and, where appropriate, financial incentives tied to the energy and carbon performance of

targeted technologies and products can boost demand for low-carbon and energy-efficient solutions.

- **Monitoring and tracking frameworks** set out the range of indicators to inform policy makers and industry of the progress, delivery and performance of sustainable and low-carbon buildings across the region.
- **Data collection** provides a means of gaining information for managing building energy use and operation, renewable energy generation, building construction and renovation practices in order to develop and regularly update baselines for tracking progress towards a net zero-carbon buildings sector and evaluating impacts of policy interventions. Robust data can also help to access project finance and develop more compelling proposals for investors.
- **Financing and investing** conditions for sustainable low-carbon building projects (both construction and renovation) through harmonising regulations and developing quality assurance programmes are vital to addressing risk adversity and broadening investment opportunities.
- **Building capacity** among governmental officials (national, subnational and local) and industry can broaden support for low-carbon buildings. Providing accessible training on building energy performance certification, sustainable urban development, materials decarbonisation, etc. accompanied by professional accreditation (e.g. certified energy managers) is critical to moving towards a net zero-carbon buildings sector.
- **Stakeholder engagement** within policy development, communication of policy priorities, and enacting and updating policies will broaden support for efforts to deliver low-carbon buildings between national, subnational and local governments based on the principles of **multilevel governance**.

Taking into account the recommendations outlined above, the AMS could consider working towards the implementation of a policy package.

An effective policy package that supports transition of the ASEAN buildings sector towards net zero-carbon covers policies from each of the seven action areas described above (urban planning, new buildings, existing buildings, materials, systems and operations, sustainable energy and resilience). It includes a combination of regulations, incentives and information policy instruments:[19]

- Regulations set minimum benchmarks and targets to give a signal to the market to phase out worst performing buildings, products and materials and set out a pathway for investments towards more efficient and low-carbon alternatives.
- A range of incentives is devoted to support the industry to adapt to the regulation at early stages of adoption to help overcome market barriers such as upfront cost

[19] For more guidelines on developing effective policy packages for low-carbon buildings, see UNEP's Handbook of Sustainable Building Policies (2013).

and access to capital and then to drive action beyond minimum standards and business as usual.

- Information tools and awareness raising campaigns intend to help consumers and developers make informed decisions about low-carbon choices for construction, renovation, purchase and lease of building spaces. Capacity building programmes aim to ensure that there are sufficient skills and knowledge on various aspects of net zero-carbon buildings, as well as an adequate number of local, qualified experts to undertake an effective implementation of policies and to drive the necessary market transformation towards net zero-carbon.

The table below summaries the main policy actions that could constitute a policy package for net zero-carbon buildings in ASEAN based on this Roadmap. Polices highlighted in the Description column serve as an indication for potential starting points for establishing the foundation of the policy package, while additional actions can be built upon it.

Establishing such a foundation could begin from setting ambitious, yet achievable, overarching targets for improving energy efficiency, decarbonising the buildings sector and communicating these targets to key stakeholder groups.

Regulatory policy instruments are critical elements when developing a policy package. Building energy codes are among the "most widely recognised, scalable" (UNEP, 2018) and effective policy instruments for buildings (Boza-Kiss, Moles-Grueso and Urge-Vorsatz, 2013). They are implemented in over 80 countries around the world. Mandatory minimum energy performance standards (MEPS) and labels for key appliances and equipment used in buildings are another fundamental policy instruments with proven evidence for its effectiveness: implemented in over 120 countries around the world. MEPS and labels "have helped more than halve the energy consumption of major appliances in countries with the longest-running programmes" (IEA, 2021c).

Once regulatory policies are in place, their effective implementation and enforcement could be supported by information policy instruments and incentives to ensure compliance and further progress. Building certification and labelling with ratings based on energy and carbon performance of buildings can provide clear signals for consumers and industry to encourage more informed and sustainable choices and practices.

A range of financial and non-financial incentives could be linked to the certification schemes to support the buildings and construction industry to adapt to the regulation at early stages of adoption and to help overcome market barriers such as upfront costs and access to capital, as well as to drive action beyond minimum standards.

Finally, capacity building programmes are crucial to ensuring that there are sufficient skills and knowledge on various aspects of net zero-carbon buildings, as well as an adequate number of local qualified experts and practitioners.

The ASEAN region, consisting of the 10 AMS, has a great variety of national circumstances in political, economic, environmental and social spheres. This regional Roadmap acknowledges that every AMS has its unique context in the buildings sector and beyond. While the Roadmap offers a comprehensive 'menu' of actions, each government can develop a suite of actions suitable to its local context and which is sufficiently ambitious to follow the pathway towards the net zero-carbon buildings sector in their country. Moreover, the milestones for policy progress at different points in the future outlined in the Roadmap are intended as indicative, and do not suggest a specific commitment for every AMS.

Policy package towards net zero-carbon buildings in ASEAN

Regulation

Policy measure	Description
Building energy codes and building standards	- clear minimal energy efficiency and thermal performance standards that are gradually strengthened with aspiration for achieving net zero-carbon building performance for all building types, both new (at the point of construction) and existing buildings (at the point of renovation). - requirements for maximum allowed amount of embodied carbon emissions in buildings' construction and renovation. - requirements for mandatory renewable energy systems installation or utilisation of renewable energy. - measures on structural and thermal resilience, and passive measures to mitigate the impact of extreme weather events or natural disasters. - requirements for regular energy audits to identify inefficiencies in building operations - requirements for regular revisions to improve performance levels (at least every 3-5 years).
Product standards	- mandatory minimum energy performance standards (MEPS) for all types of appliances and building systems - requirements for regular revisions to improve performance levels (at least every 3-5 years). - mandatory requirements for efficiency of systems and equipment used for renovation.
Procurement regulation	- requirements for assessing embodied carbon emissions using life-cycle approach for all major and public investments. - mandatory requirements to include results of embodied carbon emissions in public procurement contracts. - mandatory requirements to use highly efficient equipment and appliances, as well as low-carbon materials for public procurement.
Regulation on materials	- plans and systems for collection and reuse/recycling of construction and demolition waste. - mandatory protocols for buildings deconstruction and selective sorting of waste.
Framework regulations	- updates to existing electricity regulation or introduction of new ones to allow decentralised production, selling to the grid and peer-to-peer trading of electricity produced from renewable energy sources. - mandatory requirements for integration of decentralised renewable energy production into urban planning, as well as design of buildings and neighbourhoods. - utility regulation that mandates incorporation of renewables into utility planning - mandatory requirements to carry out feasibility assessments for district-level renewable energy and district cooling projects for new urban developments. - phase out of fossil fuel subsidies while supporting the most vulnerable people and groups to transition to renewable and other zero-emission energy sources and energy-efficient buildings. - policy frameworks for investment and finance that supports public-private partnerships and private investment in green building projects. - introduction of new urban planning guidelines or updates to the existing ones to require that subnational and local governments develop multisectoral integrated City Masterplans that include low-carbon development targets, policies and projects.

	Certification	- building certification schemes and localised rating tools on energy and carbon performance of buildings. - certification standards for existing buildings with the requirements to achieve minimal energy performance after the renovation. - requirements for materials efficiency and utilisation of materials with low embodied carbon incorporated into green building certification. - requirements for life cycle assessment included in green building certification. - regional or national databases of green and energy-efficient products for building renovation (including fabric, materials and building systems).
 **Information**	**Labelling**	- introduction of new or updates to existing mandatory rating labels and endorsement labels for new and existing buildings based on energy and carbon performance. - inclusion in the building labels of information on importance and benefits of low-carbon consumer choices when buying or renting building spaces. - mandatory labelling for main materials and components of building projects that rate them based on their carbon performance. - introduction of new or updates to existing mandatory rating labels and endorsement labels for appliances and building systems (to cover all appliance types) based on the energy and carbon performance. - regional testing laboratories to determine their performance levels and adopt mutual recognition agreements among ASEAN Member States. - ASEAN Product Registration System to monitor compliance with standards and labelling.
	Disclosure and benchmarking	- a system for regular information collection on building system operations and energy use. - disclosure and benchmarking schemes to enable comparisons and to incentivise improved performance of buildings, appliances, building systems and materials. - mandatory disclosure of energy and carbon performance information for all new construction and for large renovation projects, especially at the point of sale or lease. - benchmarks by building type based on data collected through disclosure programmes. - regular revision and update of benchmarks and targets, which are based on regular updating of materials databases.
	Training programmes	***For government officials (at the national, sub-national and local levels):*** - on sustainable development goals and the implications for urban planning solutions - on integrated policy portfolios toward achieving net zero-carbon buildings and technical solutions for net zero-carbon buildings. - on implementation and enforcement of building energy codes. - on collecting data on embodied carbon emissions of materials and building projects. - on development of integrated policy portfolios towards zero-embodied-carbon emissions buildings and construction. - on assessment of climate risks, developing vulnerability maps and establishing multi-stakeholder collaborations on the development of integrated policies to enhance resilience of the built environment.

	For developers, architects, designers, engineers and financiers: - on assessment of benefits of zero-carbon, efficient and resilient buildings. - on energy-efficient and low-carbon solutions suitable for different building types in ASEAN. - on building design and construction materials with lower embodied life-cycle carbon emissions. - on life cycle analysis, assessment of embodied carbon emissions of construction and renovation projects, ways to lower embodied carbon emissions and other circular design principles. - on compliance with regulations, certification, labelling and disclosure. ***For construction and renovation workers:*** - on utilisation and installation of energy efficiency measures and products, as well as low-carbon materials. - on the installation and operation of building energy management . ***For product and material manufacturers:*** - on solutions to decrease the embodied carbon emissions of materials, increase efficiency in manufacturing and construction processes, enhance the use of local materials, plan for end of life, increase recycling and reuse, and other circular design principles. ***For building energy managers:*** -on energy audit, fault detection, optimisation of buildings' operations and energy use. ***For building owners:*** - on building energy performance, types and benefits of energy-efficient home improvements, role of benchmarks and energy audits.
Education programmes	- energy efficiency technical training and research centres. - inclusion of information on energy-efficient and low-carbon buildings, products and materials, as well as their benefits and related policies into primary, secondary and university curricula, as well as into vocational and adult education programmes. - accreditation systems for professionals (developers, architects, designers, engineers, financiers, workers and installers), who obtain knowledge and skills on low-carbon construction and renovation. - accreditation mechanisms for building energy managers.
Awareness raising	- awareness raising programmes for consumers to inform them about the multiple benefits of efficient and low-carbon buildings. - information and awareness raising campaigns on benefits of energy-efficient renovation. - information programmes for building owners on sustainable building design and renovation, compliance with building policies and existing incentives programmes.
Digital tools and data	- use of integrated design tools (e.g. building information modelling) that include assessment of energy performance and embodied carbon of building construction or renovation projects. - requirements (first voluntary, then mandatory) for building energy management systems expanding the scope to cover all building types, new and existing buildings. - open access data framework for evaluating building-integrated renewable energy potential. - collection of spatial, climatic and socio-economic data and development of GIS databases for identifying resilience measures and building new infrastructure.

Incentives

Financial incentives	- tax rebates to manufacturers and producers of low-carbon building materials and components to supply more such products to the market at competitive prices. - tax rebates and discounts for purchase and use of certified green building materials and energy-efficient systems. - grants, favourable loan conditions, tax rebates (e.g. property tax reduction), etc. based on energy and carbon (also embodied carbon) performance of new and renovated buildings. - preferential loans or mortgages to build more energy-efficient buildings with the use of low-carbon materials and systems. - financial incentives for consumers and appliance manufacturers to promote the purchase of highly efficient appliances. - stimulus programmes to encourage investments in energy-efficient retrofits through low-interest loans, micro grants, value added tax reductions and point of sale rebates. - subsidies for building energy performance audits to encourage utilisation of building energy performance ratings and labelling. - incentives (e.g. award and penalty schemes during tender for achievement or non-compliance with a pre-defined waste reduction target) to encourage reliance on recycled or repurposed materials in the construction of new buildings. - energy performance contracts for construction and renovation of public buildings to stimulate ESCO (Energy Services Company) activities.
Non-financial incentives	- expedited development review and approvals, fee reductions, density bonuses and development allowances for buildings with high energy performance and low levels of embodied carbon. - favourable import procedures to manufacturers and producers of certified low-carbon materials and components to supply such products to the market at competitive prices.
Tariff policies	- reflective energy pricing and preferential tariffs for renewable energy, especially energy produced through distributed energy sources (e.g. net metering and peer-to-peer energy trading).

Annex

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Abbreviations and acronyms

AADCP II	ASEAN-Australia Development Cooperation Program Phase II
ACE	ASEAN Centre for Energy
AMS	ASEAN Member State[s]
APAEC	ASEAN Plan of Action for Energy Cooperation
APEC	Asia Pacific Economic Community
ASEAN	Association of Southeast Asian Nations
ASEC	ASEAN Secretariat
BAT	Building Assessment Tool
BEC[s]	Building Energy Code
BEMS	Building Energy and Management System
BIM	Building Information Modelling
BMS	Building Management System
CIS	construct industry standard
C&D	Construction and Demolition
CCUS	Carbon capture, utilisation and storage
COP	Conference of the Parties (to the UNFCCC)
CHP	combined heat and power
CSPF	cooling season performance factor
DEDE	Department of Alternative Energy Development and Efficiency, Ministry of Energy, Thailand
DSM	demand-side management
EB	Existing Buildings
EE	energy efficiency
EE&C-SSN	Energy Efficiency and Conservation Sub-Sector Network
EDGE	Microsoft EDGE
EEFD	Energy Efficiency Division of the International Energy Agency
EER	energy efficiency ratio or rating
EMGS	Energy Management Gold Standard
EMS	Energy Management System
ESCO	Energy Services Company
ESG	environmental, social, governance
EPC	Energy Performance Certificates
EPD	Environmental Product Declaration
GBC	Green Building Council
GDP	gross domestic product
GHG	Greenhouse Gas
GIS	geographic information system
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Society for International Co-operation)
GHG	greenhouse gas

GlobalABC	Global Alliance for Buildings and Construction
GPBN	Global Buildings Performance Network
IEA	International Energy Agency
IFC	International Finance Corporation
IPEEC	International Partnership for Energy Efficiency Cooperation
IRENA	International Renewable Energy Agency
LCMT	Low Carbon Model Town
LEED	Leadership in Energy and Environmental Design
LCA	life cycle assessment
NB	New Buildings
NDC	nationally determined contribution
NGO	non-governmental organisation
NZC	net zero-carbon
M	Materials
MEPS	minimum energy performance standards
OECD	Organisation for Economic Co-operation and Development
OTTV	overall thermal transfer value
O&M	operations and maintenance
PEEB	Programme for Energy Efficiency in Building
PPP	public-private partnership/ purchasing price parity [when used with a currency]
PV	photovoltaic
PVC	Polyvinyl chloride
R&D	research and development
RE	renewable energy
SAEMAS	Sustainable ASEAN Energy Management Training and Certification Scheme
SDG	Sustainable Development Goal
SDS	Sustainable Development Scenario
SEER	seasonal energy efficiency ratio
SHGC	solar heat gain coefficient
TFEC	Total Final Energy Consumption
TPES	Total Primary Energy Supply
TOD	Transit-Oriented Development
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UN ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nations Framework Convention on Climate Change
UP	urban planning
ZEB	Zero Energy Building

Units of measure

g CO_2	gram of carbon dioxide
g CO_2/kWh	grams of carbon dioxide per kilowatt-hour
Gt CO_2	gigatonne of carbon dioxide
GW	gigawatt
GWh	gigawatt-hour
KWh	kilowatt-hour
kWh/m_2	kilowatt-hour per square metre
m_2	square metre
MJ	megajoule
MW	megawatt
tCO_2/capita	tonne of carbon dioxide per capita
TWh	terawatt hour
W	watt
W/W	watts per watt

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