Accelerating Net Zero Transition of the Buildings and Construction Sector in Developing Asia and the Pacific

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I. INTRODUCTION

The buildings sector is a major source of global emissions and, as such, has been identified as a primary target for global clean energy transition and emissions mitigation efforts (IPCC 2014; Rogelj et al. 2018). From 2010 to 2019, owing to continued efficiency improvements in building envelopes, systems, and equipment, global building energy intensity decreased by 9.8%, in final energy consumption per square meter (m²) (IEA 2019a). However, this progress was not sufficient to offset the combined effect of improved access to energy, increased ownership of energy-consuming devices, and rapid growth in building floor area. These factors collectively drove up the total final energy demand from buildings. In 2019, the global final energy consumption in the buildings and construction sector increased by 8.5% compared to its 2010 level, totaling 151 exajoules (EJ) and accounting for 35% of global total final energy consumption. The total emissions of the sector, accounting for 38% of global total, reached about 13.5 gigatons of carbon dioxide (GtCO₂), consisting of more than 3 GtCO₂ of direct and 6.9 GtCO₂ of indirect energy-related emissions from buildings, as well as 3.6 GtCO₂ of energy-related carbon dioxide (CO₂) emissions from the manufacturing, transport, and use of construction materials (GlobalABC and UNEP 2020). The energy consumption of the sector was 149 EJ in 2020, a slight drop relative to the 2019 level, due largely to the change in the way existing buildings were used as a result of the coronavirus disease (COVID-19) pandemic, alongside the overall drop in the demand and production of building materials caused by the economic slowdown. Accordingly, the sectoral emissions decreased to 11.7 GtCO₂ in 2020 (UNEP 2021). Following the drop in 2020, both energy consumption and emissions of the sector in 2021 rebounded to above 2019 values (IEA 2022a). Despite these changes, the sector remains off-track from the pathway required to realize the Sustainable Development Scenario (SDS) of the International Energy Agency (IEA), and the more recent Net Zero Emissions by 2040 Scenario (NZE) (IEA 2022a).
As a fundamental determinant of sectoral energy consumption and carbon emissions, the global building stock is expected to increase by 75% from 2020 to 2050, 80% of which are projected to be in emerging and developing economies (IEA 2021c). With increasing population, continuous economic growth, and rapid urbanization, Asia and the Pacific is a major contributor to this global expansion of building stock. As projected by the IEA (2017), 65% of new floor area to be constructed from 2017 to 2050, about 70 billion m$^2$, will be in the Association of Southeast Asian Nations (ASEAN), the People’s Republic of China (PRC), and India (Figure 1). Taking India as an example, two-thirds of the buildings that will exist in 2040 in the country are yet to be built, based on the current policy settings (IEA 2021b). The building sector together with industry and transport sectors will largely shape the energy demand of the country in the coming decades. A joint report by the Global Alliance for Buildings and Construction (GlobalABC) and the United Nations Environment Programme (UNEP) has indicated that Asia will accommodate nearly half of all new constructions in the world by 2040 (UNEP 2021).
In 2018, buildings in ASEAN, the PRC, and India accounted for 27% of these countries’ total final energy consumption, slightly lower than the world average of 30%, and emitted 24% of energy-related CO$_2$ emissions of these countries, or 3.2 GtCO$_2$. In the global context, the final energy consumption and energy-related CO$_2$ emissions of buildings in these countries contributed 27% and 32% to the global total from buildings. To get on track with the IEA’s SDS, annual drops in building energy intensity per m$^2$ from 2019 to 2030 need to be at least 2% in the PRC, 4.2% in ASEAN, and 5.5% in India. These annual rates mean that building energy intensity per m$^2$ in 2030 will be reduced by 18% in the PRC, 23% in ASEAN, and 43% in India, compared to their respective levels in 2018 (IEA 2019d). These aggressive targets urgently call for sustained and effective policies and assertive actions to replenish the regional building stock with zero carbon-ready buildings at a high rate, thereby avoiding the lock-in of energy-inefficient and carbon-intensive buildings which will remain in use for decades.

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1 In these statistics for ASEAN, the PRC, and India, building energy consumption and emissions refer to the operational energy consumption and emissions of buildings, and do not include energy and emissions associated with the production and transportation of building materials and the construction activities, i.e., the embodied energy and embodied carbon.
II. BUILDING ENERGY POLICY LANDSCAPE

Globally, the policy landscape for decarbonizing the buildings and construction sector keeps evolving, as more countries are placing increasing emphasis on building energy efficiency and decarbonization as one of the major strategic options for climate change mitigation in their Nationally Determined Contributions (NDCs). Operationally, the role of building energy codes as the fundamental policy instruments to drive energy efficiency improvement of buildings is being increasingly recognized by countries. As of November 2021, 80 countries had mandatory or voluntary building energy codes at the national or subnational level (UNEP 2021). Meanwhile, certification of building energy use or more broadly for green buildings, as a major complement to building energy codes, has been more widely applied to various types of buildings. It has been proven to be an effective policy instrument to highlight best practice design and construction efforts and provide market signals to sustainability-conscious policymakers, investors, developers, and consumers.

In Asia and the Pacific, the past few years have seen encouraging progress in the overall development of building energy policy landscape of the region as a whole, although there remain large variations among countries in terms of level of ambition of sectoral targets, scope and depth of actions, policy environmental and priorities, institutional and operational capacity, and access to finance. The following sections provide an overview of the status of building energy codes, certification programs, and NDCs as the main components of the building energy policy landscape in the region.

A. Building Energy Codes

Building energy codes, or standards, are requirements set by a national or subnational jurisdiction that focus on regulating the construction and operation of buildings in order to control and reduce energy use of buildings. They can take various forms as building energy use depends on a wide range of factors, from construction typologies and building fabric choices to the operational efficiency of space conditioning systems. Building energy codes can serve as an effective policy tool for governments to mandate the construction, operation, and maintenance of energy efficient buildings, especially in countries where the building stock is driven by increasing population, rapid urbanization and rising living standards to expand fast, such as in developing Asia.
Codes can be prescriptive, meaning that they describe in detail the technical standards to be met by building components or materials to be manufactured, performance-based, where the energy level or other performance indicators of a building in use must meet a certain level, or even outcome-based, requiring a specified performance to be achieved over a certain period. Usually, codes can be formulated to be applicable to either residential buildings or nonresidential ones, such as commercial or public buildings. Apart from new buildings, codes can also target existing buildings to ensure that major refurbishments or renovations bring energy performance to a level comparable to new buildings. Codes can be mandatory or voluntary, issued at national or subnational levels. With mandatory and progressive codes, energy use can be better managed as floor space expands, and progressive codes can respond to changes in legislation and the availability of cost-effective technologies. To achieve the desired results, it is essential that a building code be adequately stringent, improved progressively over time, and implemented effectively. Also, considering code enforcement and compliance, it is important to take steps to move from voluntary codes towards mandatory codes for both residential and nonresidential buildings. It is also worth noting that, while codes typically cover the operational energy use of buildings, embodied emissions from materials and construction are beginning to be covered in some codes with the view of meeting net zero emissions standards.

In Asia and the Pacific, as of November 2021, out of the 46 countries tracked by the IEA, 24 countries had mandatory and 6 had voluntary building energy codes, while 6 were in the process of developing codes, and 13 did not have known codes. The fact that less than 50% of the countries in the region had mandatory codes clearly indicates the urgent need for greater coverage, adoption, and strength of building energy codes. If the current situation continues, it is expected that 68% of 294.3 million population to be added in Asia from 2021 to 2030 will live in countries without any building energy codes or only voluntary codes. In respect of the mandatory codes, their scope, breadth, and depth vary substantially, and they typically are less ambitious and stringent than what is required to achieve significant decarbonization and transformation towards net zero emissions by 2050. Countries and subnational jurisdictions in this region shall step up their efforts to develop and adopt building energy codes to improve the energy performance of new buildings and major refurbishments, thereby reducing future energy demand and avoiding expensive retrofits later. Meanwhile, a strong system of enforcement to ensure compliance with the codes needs to be in place and well-functioning. This has been a challenge for national and local governments because of the complexity of the built environment, its varied types and usage, and age distribution; and
the diversity of structure, materials, construction techniques, and space-conditioning strategies and technologies that are employed.

B. Green Building Certification

Green building certification schemes are comprehensive evaluation frameworks that are used to assess and recognize the compliance and performance of buildings from the perspective of life cycle resource efficiency and environmental sustainability. Usually, a scheme includes a set of explicit performance criteria against which a building that is seeking certification is evaluated, as well as related guidelines that guide the building design, construction, operation, and renovation towards meeting or exceeding the criteria. It is common that a certification scheme can cover different types of buildings, with a specific module or a subset of the scheme applicable to a specific building type. Green building certification schemes are playing an increasingly important role in promoting sectoral development. Baseline and benchmarks are established for measurement and comparison. Methods are provided to quantify a building's environmental effects, which help inform sustainable integrated design solutions and facilitate decision-making. A certified building can have better quality and performance and less adverse environmental impacts compared to what otherwise would have been the case. There are also possible benefits relating to better occupant health and higher productivity, which can be attributed to better indoor environmental quality, more access to natural daylighting, and healthier materials within green buildings. Beyond these benefits, green certification can differentiate a building and create monetary values, thus providing additional incentives to investors, developers, and owners. In a broader context, green buildings can make a significant contribution towards meeting 9 out of the 17 Sustainable Development Goals (SDGs).
Globally, a number of green building assessment tools and certification schemes have been developed by independent bodies and government agencies over the past three decades. Among them, the Building Research Establishment Environmental Assessment Method (BREEAM) and the Leadership in Energy and Environmental Design (LEED) have emerged as the leading rating and certification schemes and been the most popular and widely used worldwide. In Asia and the Pacific, in addition to LEED, BREEAM, and other international schemes such as the EDGE by the International Finance Corporation (IFC), regional and national level certification schemes have been developed and in use for buildings of various types under different climatic conditions. As illustrated in Figure 3, there has been a surge of certification schemes in the region over the past 15 years, which, to a large extent, could be ascribed to the good demonstration and successful implementation of BREEAM and LEED in Asia and other parts of the world. Some of these schemes have been updated in order to keep abreast of the development trend of green buildings against the backdrop of increasing emphasis on climate change mitigation and adaptation. Timely and appropriate updating of these schemes ensures that they are aligned with the continuously evolving building design standards and climate policies, and enhances their applicability to evaluation, rating, and certification of buildings in local contexts. For example, the ASGB in the
PRC was revised twice in 2014 and 2019. The GM of Singapore has undergone several rounds of updating since its launch in 2005, with the latest version being GM 2021.

As of 2018, 48% of countries in Central Asia, South Asia, East Asia, and Southeast Asia had adopted building energy performance certification programs, with almost 40% of them having partial mandatory or widespread voluntary certification programs (GlobalABC, IEA, and UNEP 2020). As a general trend, the use of certification scheme has been growing, with certification for high-end buildings becoming a popular means of adding value across multiple dimensions. It offers a comparative assessment of how well a building meets defined criteria for a standard and the extent to which relevant requirements are fulfilled. In some countries where building codes are absent or outdated, building certification has been used as a de facto building code (GlobalABC and UNEP 2020). However, compared to the European Union (EU), there is still a lack of large-scale adoption of full, mandatory certification schemes in Asia and the Pacific, suggesting limited tracking of stock-level building energy performance and disclosure of information. As an important tool for quality assurance during design, construction, and operation, green building certification should aim to advance the buildings and construction sector towards higher level of transparency and more ambitious building practice and performance.

C. Nationally Determined Contributions

From 2020, countries were requested to communicate their new or updated NDCs to the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC) as part of the 5-year cycle of reviewing their climate targets and commitments under the Paris Agreement. As of September 2021, 192 countries had submitted a first NDC, 113 of which were updated, and 11 countries had submitted their second NDC. Across the communicated NDCs, improvement in building energy efficiency has been explicitly mentioned in 63% of the NDCs, becoming the second most frequently indicated mitigation options following renewable energy generation (UNEP 2021).

About 72% of those countries in Central Asia, South Asia, East Asia, and Southeast Asia mentioned buildings in their NDCs by 2019. However, many still did not include specific actions to address buildings sector energy use and emissions (GlobalABC, IEA, and UNEP 2020). Following the new reporting phase beginning in 2020, various policy actions to support improvements of building energy performance and climate resilience have been increasingly mentioned in updated first or second NDCs submitted by many countries in Asia. For example,
the updated first NDC of Bangladesh highlighted the importance of LEED building certification in managing energy consumption in commercial buildings. Cambodia’s updated first NDC outlined specific emission reduction targets within the construction sector, such as a commitment to reducing brick production emissions by 44% (1.799 million tCO\textsubscript{2}e) by 2030. In Mongolia's updated first NDC, insulation of old precast panel buildings and limiting the use of raw coal and switching to the use of improved fuel in its capital city are mitigation measures for its buildings and construction sector. Tonga, in its second NDC, decided to introduce energy efficiency standards for buildings and energy performance audits, and minimum energy performance standards for appliances in buildings.

Table 1: Climate Actions Relating to Buildings and Construction in Nationally Determined Contributions of Selected Countries in Asia and the Pacific

<table>
<thead>
<tr>
<th>Subregion</th>
<th>Country</th>
<th>Actions and Measures Relating to Buildings</th>
<th>NDC Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central and West Asia</td>
<td>Azerbaijan</td>
<td>Massive use of control and measurement devices in electrical, heat energy, and natural gas systems; application of energy-efficient bulbs; use of modern energy-saving technologies in heating systems; as well organization of public awareness programs on energy use.</td>
<td>First NDC (January 2017)</td>
</tr>
<tr>
<td></td>
<td>Pakistan</td>
<td>Green building codes and certification for new and refurbished buildings, including revolving guarantee mechanism for energy-efficient appliance.</td>
<td>Updated first NDC (Oct 2021)</td>
</tr>
<tr>
<td></td>
<td>Uzbekistan</td>
<td>Further introduced energy-saving technologies in construction.</td>
<td>Updated first NDC (October 2021)</td>
</tr>
<tr>
<td>East Asia</td>
<td>China, People’s Republic of</td>
<td>Improved energy efficiency standards for new buildings and accelerate the development of ultra-low energy-consuming, near-zero energy-consuming, and low-carbon buildings on a large scale. Supported the energy-saving renovation of existing buildings in cities and towns as well as municipal infrastructures, improving their energy-saving and low-carbon level. Applied green building standards to all new urban buildings by 2025. Gradually launched limits management of energy consumption in buildings, practiced building energy efficiency labelling, and conducted performance assessment of low-carbon development in the building sector.</td>
<td>Updated first NDC (October 2021)</td>
</tr>
<tr>
<td></td>
<td>Mongolia</td>
<td>Insulated old precast panel buildings in Ulaanbaatar city. Limited the use of raw coal in Ulaanbaatar city and switch to the use of improved fuel.</td>
<td>Updated first NDC (October 2020)</td>
</tr>
<tr>
<td></td>
<td>Maldives</td>
<td>Built labelling and building standards to improve energy efficiency. Improve building code for climate resilience.</td>
<td>Second NDC (December 2020)</td>
</tr>
<tr>
<td></td>
<td>Nepal</td>
<td>Adopted national building code that emphasize low-carbon and climate-resilient urban settlements.</td>
<td>Second NDC (December 2020)</td>
</tr>
</tbody>
</table>
Table 1 provides a snapshot of measures that are relevant to buildings in some of the member economies of the Asian Development Bank (ADB). This progress is far less than sufficient, though. The breadth and depth of the mitigation (and adaptation) measures for buildings and construction as laid out in most NDCs are not adequate to put the countries in the region on track with the envisaged net zero emissions scenario by 2050. The increasing population, rapid urbanization, and growth demand for floor area and space conditioning are among the key factors that present a serious challenge to transforming the buildings and construction sector in Asia towards energy efficiency, low-carbon emissions, and climate resilience. Based on the United Nations population growth projections, it has been expected that 73% of 294.3 million population to be added in Asia from 2021 to 2030 would live in countries that have NDCs in which building codes and/or building energy efficiency measures are not mentioned (UNEP 2021). This indicates a significant gap in ambition and commitment, calling for increasing recognition of the strategic importance of buildings in NDCs and large-scale adoption of more explicit and ambitious actions and pathways to decarbonize buildings in line with the Paris Agreement.

<table>
<thead>
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<th>NDC Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southeast Asia</td>
<td>Sri Lanka</td>
<td>Introduced mandatory building energy efficiency code in 2021–2022. Established sectoral databases for eco-certification system, minimum performance and energy efficiency labelling programs, green building, and building management system.</td>
<td>Updated first NDC (July 2021)</td>
</tr>
<tr>
<td></td>
<td>Cambodia</td>
<td>Building codes, enforcement/certification for new buildings to reduce electricity consumption by 10% in 2030. Improved cooling in public sector buildings to reduce 43,000 tCO₂ per year. Passive cooling in buildings to reduce 74.5 tCO₂e.</td>
<td>Updated first NDC (December 2020)</td>
</tr>
<tr>
<td></td>
<td>Thailand</td>
<td>Relies on the implementation of the National Energy Efficiency Plan B.E. 2558-2579 (2015-2036), which aims to reduce energy demand by 30% in 2036 compared to a business-as-usual trajectory</td>
<td>Updated first NDC (October 2020)</td>
</tr>
<tr>
<td></td>
<td>Viet Nam</td>
<td>Reduced greenhouse gas emissions by replacing construction materials and improving the cement and chemical production processes together with reducing the consumption of Hydrofluorocarbons (HFCs). Improved, developed, and applied technology in manufacturing construction materials. Reduced clinker content and implemented other measures to reduce greenhouse gas emissions in cement production. Developed and used energy-saving construction materials and green materials in housing and commercial sectors</td>
<td>Updated first NDC (September 2020)</td>
</tr>
<tr>
<td>Pacific</td>
<td>Papua New Guinea</td>
<td>Improved building insulation and energy efficiency. Introduced building codes to mitigate impacts of heat waves and cyclones and for adaptation.</td>
<td>Second NDC (December 2020)</td>
</tr>
<tr>
<td></td>
<td>Tonga</td>
<td>Introduced energy efficiency standards for buildings and energy performance audits and minimum energy performance standards for appliances in buildings.</td>
<td>Second NDC (December 2020)</td>
</tr>
</tbody>
</table>

NDC = Nationally Determined Contribution, tCO₂e = ton of carbon dioxide equivalent.
Source: UNFCC (2022).
III. IMPACTS OF ENERGY-EFFICIENT AND LOW-CARBON BUILDINGS

Through promoting energy-efficient and low-carbon buildings, multiple crosscutting benefits and advantages can accrue to the buildings sector and related stakeholders. They relate to non-energy, non-carbon, and macroeconomic benefits through indirect cost savings such as improving energy security and resilience; generating employment; improving the health, productivity, and comfort of building occupants; and improving asset values (Allouhia et al. 2015; Kamal, Al-Ghamdi, and Koc 2019). These benefits are also well aligned with and contribute to various SDGs, namely SDG-3 Good Health and Well-being, SDG-7 Affordable and Clean Energy, SDG-11 Sustainable Cities and Communities, SDG-12 Responsible Consumption and Production, and SDG-13 Climate Action (DGNB 2021). Positive impacts of these benefits are already being measured and quantified in many developed economies where aggressive energy efficiency and decarbonization policies have been implemented in the buildings sector. These provide valuable references for developing Asian economies to pursue evidence-based decarbonization policies in the buildings sector.

Monetary benefits. According to an IFC report, green buildings that include energy efficiency improvement feature a long value chain, involving multiple market players such as material manufacturers, planning and design, and provide huge low-carbon investment opportunities in emerging countries, with market size of $24.7 trillion by 2030 (IFC 2019). Of this total, $17.8 trillion are in East Asia, Southeast Asia, and the Pacific, and $15.7 trillion in the residential sector. Research has suggested that only ambitious policy frameworks supporting building energy efficiency decarbonization towards net zero by 2050 would translate into a positive financial return on investment (ROI), whereas moderate policies rarely yield a long-term positive ROI (Ürge-Vorsatz et al. 2015). Modelling focusing on costs and benefits of energy efficiency renovation of buildings in the EU demonstrated that an investment of €39.8 billion in cost-effective renovation measures could result in savings of €56 billion, achieving an ROI of +1.4 (Copenhagen Economics 2012). In a case study conducted in Germany, the present value of energy cost savings from improving building energy efficiency over a 30-year lifetime amounted to €661 million, resulting in a benefit-cost ratio of 1.06 (Levine et al. 2012). The direct and co-benefits of energy efficiency measures combined have the potential to add 1% growth in gross domestic product (Copenhagen Economics 2012).
Energy efficiency measures can increase the property value of buildings (Jensen, Hansen, and Kragh 2016). An EU report that conducted macroeconomic benefits of energy efficiency revealed that better-performing buildings attracted an increased sale value of 5.2%–35% in the commercial sector and up to 14% in the residential sector. The corresponding increases in rental values were 2.5%–11.8% for commercial properties and 1.4%–5.2% residential properties (Pollitt et al. 2017). The IFC report highlighted that there was evidence that new green buildings "can decrease operational costs by up to 37%, achieve higher sale premiums of up to 31% and faster sale times, have up to 23% higher occupancy rates and have higher rental income of up to 8%" (IFC 2019).

**Energy security and infrastructure savings.** Given the high share of buildings in final energy consumption in most countries, decreasing energy demand for building operations and improved energy efficiency of industrial processes (e.g., production of cement and steel as major building materials) can contribute significantly to reducing the need for imports of primary energy and that for investment in power generation capacities. This may even result in a decline of energy price as demand drops. The IEA estimated that worldwide energy efficiency improved by an estimated 13% between 2000 and 2017, most of which was achieved in building and industry sectors. The estimated amount of primary energy saved in major economies in 2017 as a result of efficiency gains since 2000 was more than 50 EJ, of which about 40% came from reduced fuel input to power generation because of reductions in electricity demand. During the same period, efficiency gains in IEA countries and other major economies avoided the need for more than 11 EJ or 20% more fossil fuel imports in 2017, of which avoided oil imports in IEA countries alone were worth more than $30 billion (IEA 2019b). Lower imports bolster regional and national energy security, and also bring broader macroeconomic benefits, including an improved national balance of payments and increased public budgets and competitiveness.

In the United States, energy efficiency programs across 20 states delivered energy savings of $29 per megawatt-hour (MWh) to $79/MWh, with the average saving of $46/MWh. In this case, investing in energy savings costed less than half as much as supplying the same amount of retail power, and was lower than the cost of providing new supply (Hoffman et al. 2015). Some studies have concluded that energy efficiency can be the lowest-cost energy resource available to energy utilities (Kamal, Al-Ghamdi, and Koc 2019). Energy savings can also reduce overall peak energy demand and, therefore, help to provide more electricity to consumers without the need to building new power generation capacities. The savings can be substantial, if considering what it would have costed to generate energy versus how much energy efficiency measures cost. Therefore,
energy efficiency is counted as an important solution for addressing energy poverty by securing access to affordable and sustainable energy (UNEP 2019).

**Employment.** Globally, direct and indirect employment opportunities have been created as a result of implementing building energy efficiency and decarbonization policies and investments. Demand for more labor has stemmed from subsectors and areas such as advanced manufacturing for new material, data collection devices, innovative heat pumps, improved building design, and appliances. Locally manufactured energy efficiency equipment has the potential of high growth rates. Increasing employment opportunities can lead to an average increase in available income at various levels of education. In some specific jobs, it stimulates further qualification and improves the overall skill set (DOE 2017). These findings were supported by an EU report, which projected the creation of 0.8 million jobs in 2020 because of building energy efficiency measures, with energy service companies (ESCOs) being the main driver (Pollitt et al. 2017).

Research has found that each $1 million invested in energy-efficient buildings would generate an average of 14 job-years of net employment (Gouldson et al. 2018). In Europe, the European Energy Performance in Buildings and Energy Efficiency Directives were found to have produced an employment effect in the range of 10–19 direct jobs per €1 million invested in building energy efficiency. In Germany, similar investment volume in building energy efficiency were estimated to have created up to four indirect jobs in addition to the predictable direct jobs (Ürge-Vorsatz et al. 2010; Economidou et al. 2011; Meijer et al. 2012).

**Productivity.** Building energy efficiency can be seen as an energy service that provides a range of energy and non-energy productivity gains in the construction value chain. Introducing new technologies or more stringent building energy regulatory requirements can lead to large cost savings from a life cycle perspective. In Australia, builders were able to reduce their original cost premiums by half for moving to more stringent National Home Energy Rating Scheme (NATHERS) requirements. These savings were achieved because of greater economies of scale and improvements in the construction supply chain (UNEP 2019). In case of the EU, the estimated productivity gains range between €53.4 million and €88.9 million per annum from 2020 to 2030 (Pollitt et al. 2017). Data from Germany showed that additional total costs for meeting cost-effective near-zero energy building standards ranged between 2% and 8%, similar to the range of typical fluctuations of construction costs in standard construction (BPIE 2013).
Improved thermal comfort and indoor environment quality, often as a result of improved energy performance of buildings, can lead to improved productivity of occupants. Studies of office workers in certified green buildings in the United States showed that worker productivity in ‘green’ offices was 2%–3% higher than standard offices, and that these gains were equivalent to annual energy costs. Tenant satisfaction was also found to be higher in green office space (Edwards 2006; Amos, Zhang, and Chan 2017). Improving indoor environmental quality in existing United States office buildings was estimated to be able to increase productivity by 0.5%–5.0% and deliver annual economic value of $12 billion–$125 billion (Kosonen and Tan 2004).

The realization of the abovementioned potential benefits is often subject to a range of barriers that create real or perceived risks to implementing policies and investments and achieving envisaged outputs and outcome. While the nature and likelihood of risks are highly context-specific, some common typologies of barriers, which are mainly on the policy front, involve the following.

**Political and institutional barriers.** Implementing low-carbon policies in the building sector requires a strong commitment to continual improvement over medium to long term, which may cover many election cycles. Policy design and implementation often requires extensive coordination across government agencies and between different levels of government. These complexities and dynamics often lead to conservative incremental improvements in policy stringency rather than ambitious step-changes towards decarbonization (Allouhia et al. 2015; Harrington and Tolle 2017).

**Economic barriers.** These can include increases in upfront costs of higher energy performance buildings and equipment, lack of available finance to address upfront costs, and poor understanding of life-cycle costs (and benefits) of maintaining high performance in operations (UNEP 2019).

**Social barriers.** The behavior and social practices of building occupants have a significant influence on the gap between predicted and actual building energy performance. These factors are complex to address and are influenced strongly by emotional rather than rational decision-making (UNEP 2019). Studies have shown that whether or not the occupants are directly responsible for energy bills would have a strong influence on their energy consumption behaviours in buildings (Delzendeh et al. 2017).
Knowledge barriers. These barriers range from a lack of professional capability to design and construct high-performance buildings, to a lack of capacity or training in policy design and implementation. Performance data is not always sought-after by building professionals (Way and Bordass 2005). Data on energy cost savings and returns on investment lacks consistency and transparency, thus being poorly trusted by investors (Allouhia et al. 2015). This contributes to the building sector having no consistent evidence base (Criado-Perez et al. 2020), which deters investment and market growth.

Overcoming these barriers to implement policies towards realizing benefits will inevitably incur costs. In practice, designing and implementing building energy efficiency and decarbonization policy, as in the case of any policies, will generate multiple costs and benefits, which need to be factored in when evaluating the cost-effectiveness of the policy. The overall direct cost of a policy intervention is normally calculated as a function of the additional costs incurred by all affected stakeholders, including public authorities, policy implementers, and end-users. These can either be one-time costs, or a sum of repeated investments discounted over the lifetime of a policy intervention. Costs to industry of responding to changes in building codes are generally assumed to be passed on to consumers. The monetary benefits of a policy are normally calculated as a function of the monetary value of energy saved by the policy over its lifetime. However, costs and benefits of promoting low-carbon and energy-efficient buildings accrue to different stakeholders at different times during the building life cycle. These points in time span periods that are often longer than election cycles. The construction and real estate industries often over-estimate the costs of energy efficiency improvement and carbon emissions reduction, and under-estimate the financial benefits, thus being reluctant to make investments. Governments also incur administrative and transaction costs which differ, depending on the role of a jurisdiction in the governance of building codes. Therefore, determining the cost-effectiveness of a policy is both a technical and political calculation (UNEP 2019).

IV. ROAD MAP TO ZERO CARBON-READY BUILDINGS IN DEVELOPING ASIA

Globally, the buildings sector is not on track with IEA's NZE by 2050 Scenario (IEA 2022a). To get on track, the sector needs to undergo a step change improvement in the energy efficiency and flexibility of the building stock. A complete shift away from fossil fuels is an integral part of this change. To achieve this change, more than 85% of buildings need to comply with zero carbon-
ready building energy codes by 2050. This means that mandatory zero carbon-ready building energy codes for all new buildings need to be introduced in all regions by 2030, and that energy retrofits of most existing buildings need to be carried out by 2050 to enable them to meet zero carbon-ready building energy codes (Table 2). Here, zero carbon-ready buildings refer to highly energy-efficient and resilient buildings that either use renewable energy directly, or rely on an energy supply that will be fully decarbonized by 2050, such as electricity or district heat (IEA 2021d). This means that a zero carbon-ready building will become a zero carbon building by 2050, without any further changes to the building or its equipment. It reflects the fact that the building itself will have achieved what it could to get as close to zero carbon (GlobalABC, IEA, and UNEP 2020). The zero carbon-ready concept include both operational and embodied emissions (IEA 2021c).

Table 2: Building Sector Pathway to Net Zero Emissions by 2050 under International Energy Agency Net Zero Emissions Scenario

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Emissions (GtCO₂)</th>
<th>Buildings Emissions (GtCO₂)</th>
<th>Recommended Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>33.9</td>
<td>2.9</td>
<td>No new sales of fossil fuel boilers by 2025.</td>
</tr>
<tr>
<td>2030</td>
<td>21.1</td>
<td>1.8</td>
<td>All new buildings zero-carbon ready. Universal energy access.</td>
</tr>
<tr>
<td>2035</td>
<td>12.8</td>
<td>1.2</td>
<td>Most appliances and cooling systems sold are best in class.</td>
</tr>
<tr>
<td>2040</td>
<td>6.3</td>
<td>0.7</td>
<td>50% of existing buildings retrofitted to zero carbon-ready levels. 50% of heating demand met by heat pumps by 2045.</td>
</tr>
<tr>
<td>2050</td>
<td>0</td>
<td>0.1</td>
<td>More than 85% of buildings are zero carbon-ready.</td>
</tr>
</tbody>
</table>

GtCO₂ = gigaton of carbon dioxide.  
Source: (IEA 2021c)

While the IEA's NZE report does not provide details on region-specific pathway, there is no doubt that buildings in Asia will need to undergo a pathway and achieve milestones similar to, if not more ambitious than, the global building stock-listed in the Table 2. In fact, key factors like large geographical coverage, distinct climatic conditions, increasing regional population, rapid urbanization, and growing demand for space conditioning collectively tend to make the decarbonization of the total building stock of the region as a whole even more challenging than many other parts of the world. This can be clearly exemplified by the future trend of region's building energy intensity reduction. As shown in Figure 3, to get on track with IEA's SDS by 2030, developing Asian economies (excluding the PRC) would need to reduce region-wide average building energy intensity per m² by 45% relative to the 2019 level. In contrast, the needed reduction would be considerably lower in other regions, e.g., 23% for Europe, 22% for North America, and 31% for the world. This challenging target urgently calls for sustained and effective
policies and assertive actions to avoid the lock-in of energy-inefficient and carbon-intensive buildings in the region, and replenish the regional building stock with zero carbon-ready buildings at a high rate.
As in other parts of the world, a transformation of the buildings and construction sector in Asia is required to decarbonize buildings across the entire life cycle. Reaching net zero operational and embodied carbon emission buildings is possible, but requires clear and ambitious policy signals to drive a range of actions and measures including passive building design, material efficiency, low-carbon materials, efficient building envelope measures, and highly efficient lighting and appliances. Both new and existing buildings shall be targeted. To accelerate and scale up actions, greater collaboration involving a range of stakeholders is needed, including policy makers, urban planners, architects and designers, construction companies, equipment and materials suppliers, utilities, developers, and investors. Some of the key actions are discussed as follows.

A. New Buildings

With the expected fast expansion of building stock driven by increasing population, rapid urbanization, and continued economic growth in the region, it is of strategic significance that new buildings are designed and constructed towards the standard of (nearly) net zero operating emission performance, in order to avoid the lock-in of large volume of operating emissions from inefficient buildings for multiple decades. Key policy actions, design strategies, and technological options for new buildings include:

(i) Develop and implement mandatory building energy codes. Transition existing voluntary to mandatory codes that set the minimal energy efficiency, and thermal
performance in new buildings should be accelerated to the extent possible. Codes should expand the scope to cover all types of buildings, set or refer to guidelines for locally adapted bioclimatic design principles to optimize passive design, and take a whole life cycle approach by increasingly incorporating explicit requirements on embodied energy and/or embodied carbon of building materials.

(ii) Strengthen building energy codes. A building code improvement cycle should be established to strengthen the performance requirements on a regular basis, e.g., every 3–5 years, with the aim of achieving net zero carbon emission codes over the medium to long term. Meanwhile, enforcement of and compliance with building codes are crucial yet challenging because, often, it is up to subnational governments to enforce and monitor. In addition to turning codes from voluntary to mandatory, effective compliance monitoring framework with penalty mechanism will play an important role.

(iii) Adopt energy efficiency design strategies and technologies to reduce the demand for space conditioning (cooling/heating). For countries located in climate zones that are cooling-dominated or having significant cooling demand during summer, the overarching objective is to minimize the cooling demand and reduce the use of mechanical ventilation and cooling systems while avoiding the occurrence of overheating and thermal discomfort. The cooling strategy should cover controlling solar heat gains (orientation, built form, shading, thermal mass, windows and glazing, reflective surface); choosing appropriate ventilative cooling techniques; applying low-energy cooling technologies; harnessing cooling energy from renewable sources; and using sustainable air distribution systems. For countries with long heating season, it is important to promote and scale up the applications of higher-efficiency heating technologies and renewable energy as a clean heat source, such as various heat pump technologies, and solar space heating. In this context, taking an integrated design approach by employing modelling and simulation tools can help ensure higher performance in a cost-effective manner.

(iv) Integrate on-site renewable energy. At the building level, on-site renewable generation can be one of the feasible strategies to achieve net zero energy and net zero emissions targets. Buildings may fully or partially meet their energy needs with local electricity and/or heat generation systems using renewables, such as solar photovoltaics, building-integrated photovoltaics, solar thermal, geothermal, micro-wind, and thermal energy storage. Lowering regulatory and financial
barriers is key to accelerate the widespread adoption of these technologies in the planning and design of buildings and neighborhoods (GlobalABC, IEA, and UNEP 2020). Renewable energy sources can also be integrated with space cooling solutions through careful planning, design, implementation, and operation. Commonly applied combinations include geothermal energy, solar heat, or waste heat coupled with absorption or adsorption-based cooling cycles. Compared with conventional systems, these cooling systems consume much less electrical and use refrigerants and absorbents/adsorbents that do not emit greenhouse gases (Maidment and Paurine 2012; Sarbu and Sebarchievici 2017).

(v) Building labelling. Quantitative building energy labelling can be used to assess “as designed” building performance on a scale of less to more efficient. Labelling enables increased information sharing and awareness for consumers and investors. Labelling can also be linked to incentives and financial tools (GlobalABC, IEA, and UNEP 2020). Certification, such as green building certification as discussed in previous section, is included in this policy as another form of performance assessment and recognition. Labelling and certification systems should be continually monitored and improved to ensure the rating accurately reflects the actual design and performance of the assessed buildings.

(vi) Mobilize sustainable building investments. Policies and measures should be put in place to facilitate design and construction of low carbon buildings by increasing access to and use of finance to enable private sector investment. To this end, fiscal incentives, such as rebates or tax reductions, could be awarded to the best performing buildings to promote good design and operations. Non-fiscal incentives, such as expedited permits or increased floor area allowances, could also be effective.

B. Existing Buildings

Given the large size of existing building stock, more attention shall be given to the increasing need of renovating and upgrading existing buildings of various types to improve their quality and performance. In practice, it will be key to make the most of building upgrades for reasons other than energy performance and use those opportunities to renovate or upgrade the buildings envelope, systems, and operation.² To reduce operational carbon emissions, renovations to the

² In this regard, using some simple tools for a back-of-envelope calculation of the current energy consumption and CO₂ emissions of the buildings will be useful to allow building owners to understand the potential of energy savings and emission reduction and evaluate plausible options for energy-related renovations before conducting more
building envelope and systems will be crucial, and should be carried out towards reaching the performance standards of new buildings.

(i) Increase renovation rates. Under IEA's SDS, annual rates of renovating existing buildings in Asia for improved energy performance should reach 1.5% by 2025 and 2% by 2040. Buildings should be retrofitted to their cost-effective potential as quickly as they can, even if this happens over the course of several years (GlobalABC, IEA, and UNEP 2020). According to the modelling of IEA's NZE pathway, achieving decarbonization of energy use in the building sector will require almost all existing buildings to undergo a single in-depth retrofit by 2050 (IEA 2021c). Priorities of the retrofit are similar to those design strategies and technologies that are applicable to new buildings as mentioned above. Among them, it is noteworthy that applying reflective surface finishes to buildings can be a very effective and relatively low-intrusion measure to control solar radiation and heat gain and reduce cooling demand, which is a key challenge to many countries in South Asia and Southeast Asia.

(ii) Increase the depth of renovation. Internationally, according to IEA's Energy Technology Perspectives, building energy retrofit was found to be typically less than a 10%–15% energy intensity improvement (IEA 2017). A similar observation was given by the global status report for buildings and construction (GlobalABC, IEA, and UNEP 2019). These improvement rates would not be adequate to achieve the emission reductions required for the envisaged SDS, or the more recent NZE by 2050 Scenario, i.e., the building sector is not on track. Deep energy retrofits are needed to reduce energy consumption of existing buildings by 30%–50% or more. In Asia, the building stock that is greater than 25 years old will begin to require more substantial maintenance and refurbishment, particularly in large urban centers across the region (GlobalABC, IEA, and UNEP 2020). Retrofit for better thermal performance and higher energy efficiency could be an integral part of the refurbishment.

(iii) Codes for existing buildings. As in the case of new buildings, building energy detailed analysis and making investment decisions. For example, the Interactive CO2 Calculator on the Federal geoportal of the Switzerland allows users to obtain an initial estimate of the CO2 emissions for every residential buildings in the country and find out for each of them how a change of energy source, for example from natural gas to a heat pump, or a building refurbishment can reduce emissions (https://www.bafu.admin.ch/bafu/en/home/topics/climate/info-specialists/reduction-measures/buildings/calculator-co2-buildings.html ).
codes for existing buildings are a fundamental policy instrument to govern renovation work for quality control. In many developing economies in the region, such codes are not available and, where they are available, they are typically voluntary. Support needs to be provided to countries to develop codes for existing buildings to ensure that renovation will be carried out to align the performance of existing buildings with their cost-effective potential, and the energy retrofit, either as a stand-alone activity or as part of the renovation, will deliver the intended results of energy efficiency improvement.

(iv) Building labelling and certification may also be applicable to existing buildings to assess the performance of building envelope and system characteristics following renovation. Currently, good progress in this regard has already been made in some countries in the region, such as the Indian Green Building Council (IGBC) rating system for existing buildings, and Malaysia's Green Building Index (GBI) for existing buildings. As for incentives for energy retrofits, the aforementioned fiscal and non-fiscal incentives for new buildings are also largely applicable to existing buildings.

(v) Demonstration projects. In countries where building renovation is not yet a widespread practice, government-led initiatives to renovate public buildings for energy efficiency and low emissions can provide the needed demonstrational effect and help with creating the market and developing capacity.

C. Building Systems and Operations

Electricity consumption of building systems, lighting, and appliances accounts for a substantial share of building energy consumption and results in large amount of (indirect) carbon emissions. They have shorter lifetime and therefore higher turnover rates than buildings, thereby providing large potential to reduce emissions that are attributable to buildings, both new and existing. For large buildings, such as commercial office buildings or public buildings, better energy management tools and operational practices can reduce the amount of operating energy and emissions. This is relevant to both new and existing buildings.

(i) For building systems, lighting, and appliance, it is important to develop, enforce, and progressively improve standards that set product quality and performance requirements. In Asia, minimum energy performance standard (MEPS) are beginning to be more widely adopted across the region. For example, India,
Singapore, and Viet Nam have adopted mandatory MEPS for lighting, air conditioning, and a range of appliances. A study by the IEA has found that ASEAN governments have scope to significantly raise their MEPS for air conditioners in line with the SDS, without harming local industry or raising costs for consumers. In addition, there is potential for the development, or enhancement, of labelling programs that raise consumer awareness and increase the share of more efficient air conditioners in the region (IEA 2019c). Mandatory MEPS for key energy-consuming building services should be established and implemented in more countries. MEPS should also set limits regarding global warming potential of refrigerants and emissions of indoor air pollutants.

**Box 1: Role of Regulatory and Market-Based Mechanisms to Improve the Efficiency of Space Cooling**

Regulatory and market-based mechanisms can complement each other for improving the efficiency of space cooling equipment in a country. In Figure B1, the area under the inverted bell curve represents the stock of cooling equipment in a country. On the extreme left is the portion that is noncompliant with minimum energy performance standard (MEPS) requirements. The center of the curve is the bulk of the stock, which complies with MEPS and forms the business-as-usual technologies of space cooling in the country. On the extreme right is the portion of super-efficient cooling equipment in the stock.

**Figure B1: “Push” and “Pull” the Market for Improved Space Cooling Efficiency Improvement**

The MEPS raise the baseline efficiency of cooling equipment in the country and “push” the market towards regulatory compliance, while the labelling systems, incentives, and research and development collectively “pull” or motivate the market to move towards higher energy efficiency. The role of labelling is crucial as it promotes the purchase of energy-efficient cooling equipment of a high standard, and drives up market demand for such products. The overall energy performance of the country’s space cooling stock will continuously improve in the presence of a favorable ecosystem such as effective enforcement of cooling equipment MEPS, incentives for purchasing efficient equipment, availability of equipment efficiency testing laboratories, and continuous research and development facilities.


(ii) Quantitative labelling of the embodied energy and carbon and their life cycle energy and carbon performance of products enables consumers to make informed decisions, and also facilitates the implementation of incentives, MEPS, and phase-out programs. Government procurement of building-related products and services based on energy efficiency and/or environmental standards can also play an important role in supporting the effort to phase out unsustainable products and services.

(iii) For large buildings, particularly commercial buildings, building energy management system can be used to monitor and control energy-related building services plant and equipment, identify anomalies and faults, facilitate maintenance, understand energy consumption patterns, and improve energy performance. Smart and advanced sensing and control technologies can play an important role in collecting and processing data on building occupants' perception of indoor environment and optimizing system setting for thermal comfort and energy efficiency. Audit tools can help identify priority retrofit measures and provide inputs to building energy system optimization, particularly for buildings with high energy consumption.

D. Building Materials

In designing and developing buildings, a life cycle approach shall be taken to reduce the environmental impact of materials and equipment in the buildings and construction value chain. This is particularly important in many developing economies in Asia where increasing population,
rapid urbanization, and strong economic growth are driving up the demand for housing and commercial buildings, particularly in large cities. The following describes a range of actions and measures that can be taken to address embodied energy and carbon of buildings (GlobalABC, IEA, and UNEP 2020). Their relevance and applicability vary substantially across the region because of the large differences among countries in terms of differences in size, composition, structural types, main materials, design standards, construction techniques, and age distribution of the building stocks, as well as the development of real estate market and construction industry.

(i) Develop strategies to decarbonize building materials and set targets for overall embodied carbon and/or embodied energy of buildings. The strategies will need to rely on comprehensive data collection efforts and the development or adaptation of standardized tools and benchmarks to assess embodied carbon and/or embodied energy and set performance targets of reduction over established baseline. Specific targets should be set for the subsectors and in particular for major materials used such as cement and steel, while promoting low-carbon and nature-based solutions for building materials.

(ii) Reduce primary material demand through optimized design, optimized building techniques, more intensive use of existing materials, and the reuse of scrap materials are cost-effective measures to reduce embodied carbon of buildings. At the same time, low-carbon alternative materials should be used where possible, such as clinker substitutes for cement production. It is also important to encourage and incentivize good practices, such as promoting concrete-steel composite construction, reducing cement content in concrete, and lower clinker-to-cement ratio.

(iii) Energy intensity or carbon intensity of building material production, i.e., energy use per unit of material production, should be tracked and benchmarked against the intensity level using best available technologies and practices. This will allow manufacturers to set targets, and for the industry to develop minimum standards. The adoption of best available technologies and practices should be promoted across all sectors. Building material manufacturing should be included as an integral part of demand-side energy management policies and actions. It is also important to encourage manufacturers to use cleaner energy where possible, e.g., switching from coal to gas, electrification of processes, use of solar energy, and waste heat recovery and utilization.
Stimulate markets for low-carbon products and materials. Implement policies that enable improved design and purchasing decisions based on embodied carbon and energy. This could be achieved through combining push levers (e.g., carbon pricing, tax incentives, subsidies, and regulations on production of materials) with pull levers (e.g., public procurement and regulations on the construction sector). Appropriate policies should be developed to promote government buildings use of low-carbon and efficient materials based on life cycle analysis.

Promote a circular economy by developing cradle-to-grave or cradle-to-cradle life cycle approaches in the buildings sector to enable a systemic, material-neutral, and performance-based approach and business models. Integrate whole-life-cycle carbon thinking into planning and design processes. Develop strategies for repurposing of buildings when appropriate. Mandate plans and systems for collection and reuse and recycling of construction and demolition waste. Improve demolition processes including via the development of guidelines or protocols for demolition and selective sorting of waste.

E. **Urban Planning**

The systemic nature of net zero emissions means that strategies and policies for buildings will work most effectively if they are integrated into overall urban planning and aligned with strategies and policies for related sectors. At the urban scale, the siting of buildings has both direct and indirect impacts on energy use by buildings, as well as fuel consumption by various transport modes. Urban form is an important determinant of urban energy (and transportation) demand, encompassing the overall physical characteristics of the built environment, such as shape, size, density and configuration, the street network, and public spaces. Likewise, at the building scale, compactness, height, orientation, and mutual shading are important design factors that collectively have a great impact on energy demand in buildings and also thermal comfort and indoor air quality of the built environment (Box 1). As buildings are typically governed by rules set in urban planning policies and regulations, their impact on energy consumption and potential for local energy production should be taken into consideration when formulating urban planning and land-use policies and programming development projects (GlobalABC and UNEP 2016; GlobalABC, IEA, and UNEP 2020). For example, integrating strategies and policies for buildings with those for power systems would help with the scaling up of building-integrated photovoltaics technologies, battery storage, and smart controls to make buildings active service providers to
power grids. It would also help foster the deployment of smart electric vehicle-charging infrastructure (IEA 2021c).

Box 2: Impact of Built Form, Orientation, Wind Direction

For building blocks such as buildings in a residential compound, there is a possibility to benefit from mutual shading to minimize solar exposure of building elevations during summer (Figure B2). The effectiveness of mutual shading depends on a building's latitude and location with respect to the other buildings, height of the context buildings, and distance between the buildings (Bureau of Energy Efficiency 2014). The benefits of mutual shading in reducing the solar exposure are possible if the buildings are closely placed to the east and west of the reference building. There is less shading effect from the buildings located south of the reference building, with the minimal shading effect during peak summer. Except in tropical climates where the latitude is low, there is negligible shading from the buildings located north of a reference building.

Figure B2.1: Taking Advantage of Built Forms for Mutual Shading


In addition to exposure of solar radiation, prevailing wind direction is another important factor to consider when orienting a building. This is particularly relevant to hot-humid and warm-humid climates where the full potential of natural ventilation and cooling should be availed of. To do so, a building needs to be oriented at an angle to the prevailing wind direction to facilitate maximum air flow and cross ventilation through the building. Often, this direction does not
necessarily coincide with the preferred sun orientation. Thus, it is not possible to optimize both design parameters simultaneously, which means a trade-off between them. In this case, a reasonable compromise should be made based on a detailed analysis on the specific situation. Possibilities for diverting the wind direction by means of vegetation and/or structural arrangements should be explored, such as the use of parapet walls within the external adjoining space. As a rule of thumb, low-rise buildings usually would not receive much solar radiation, and therefore could be oriented according to the prevailing wind direction to maximize the benefit of natural ventilation. For high-rise buildings, on the contrary, the priority should be given to best orienting the building for minimizing solar radiation and heat gain. When there are buildings on a site, they should be properly laid out such that minimal wind shadows would be created, and wind movements could be accentuated (Figure B2.2).

![Figure B2.2: Building Orientation and Prevailing Wind Direction](image)


V. RELEVANCE TO ADB STRATEGIES AND OPERATIONS

A. Buildings as a Priority in ADB Strategies and Policies

ADB has a long-standing commitment to increasing investment in energy efficiency, mainly supply-side energy efficiency, and the use of renewable energy in its member economies. Over
the past decade, ADB spent on average more than 20% of its portfolio in the energy sector, which amounted to more than $42 billion. Many member economies have yet prioritized demand-side energy efficiency, despite its great potential and co-benefits, but focusing on developing renewable energy and strengthening power grid. From 2016 to 2020, ADB invested $3.6 billion in energy efficiency, of which $2.7 billion was on supply side projects that reduced technical losses and $838.7 million on demand side interventions such as smart meter systems (ADB 2021).

In 2018, ADB approved the new long-term Strategy 2030 to respond to the region’s dynamically evolving development needs. ADB’s Strategy 2030 prioritizes demand-side energy efficiency through operational priority 3 on tackling climate change, building climate and disaster resilience, and enhancing environmental sustainability; and emphasizes building energy efficiency as well as access to renewable heating and cooling through operational priority 4 on making cities more livable. An independent evaluation on ADB’s energy sector strategies and operations carried out by ADB’s Independent Evaluation Department has identified demand-side energy efficiency as one of the five key significant areas to be prioritized and scaled up by ADB’s energy sector operations in more member economies (ADB 2020).

In ADB’s new Energy Policy issued in 2021, the expanding efforts from the supply-side to demand-side energy efficiency and cross-sector operations have been highlighted. In particular, promoting cleaner cooling and heating has been identified as one of the prioritized operational areas under the Energy Policy's first guiding principle relating to securing energy for a prosperous and inclusive Asia and the Pacific. Recognizing the rapidly mounting demand for cooling and indoor thermal comfort in tropical and subtropical climate zones, ADB will support its member economies in formulating necessary policies and designing investment programs to accelerate the introduction and adoption of state-of-the-art sustainable cooling solutions. Renewable energy-based, energy-efficient, and thermally driven technologies and systems are among those considered highly relevant, applicable, and scalable in the context of fast-developing Asian cities. For heating, the Energy Policy has highlighted the competitive advantages of heat pumps and the strategic role that they can play in decarbonizing heat generation and supply, which is still dominated by fossil fuels in many Asian countries. There is large potential for various types of heat pumps, e.g., air-source, water-source, or ground-source, to be applied in these countries. As stated in the Energy Policy, ADB will assist member economies in availing of the benefits of heat

pumps, through knowledge generation and demonstration projects that will help leverage project financing. In parallel with specific technologies, promoting demand-side energy efficiency through policy support, use of innovative financing instruments, and mobilization of private sector resources has also been identified by the Energy Policy as a priority for ADB operations. Residential and commercial buildings are among those key target areas of these cross-sector and cross-thematic interventions.

One of the development solutions in ADB’s Urban Sectoral Directional Guide, which has been approved in November 2022, focuses on clean and low-carbon urban energy. It identifies sustainable cooling, clean and efficient heating, and digitalization and smart controls in built environment as subareas for prioritization. A series of actions are formulated based on the criteria of strong relevance to ADB operations and ease of implementation, scalability, and replicability in member economies. Further, the ongoing preparation of ADB’s Climate Change Action Plan, which, upon approval in 2023, will guide ADB’s climate-related operations up to 2030, is defining a series of thematic areas for enhanced climate actions. Decarbonization of buildings is identified as a mitigation priority that will play an important role in supporting ADB member economies to implement their NDCs and contributing to ADB’s ambition of delivering $100 billion climate finance by 2030.

It is evident that the importance of supporting countries with developing energy-efficient and low-carbon buildings has been increasingly recognized in the evolution of ADB’s key institutional documents over the past 5 years. To translate this strategic priority into concrete interventions, upstream engagement with governments needs to be strengthened to integrate the issues and opportunities of the buildings and construction sector into country partnership strategies and design programs and projects that can most cost-effectively promote the sectoral transformation towards net zero emissions.

B. Proposed Areas for ADB Support
The scale of existing stock, rate of annual new construction, and energy intensities of residential and commercial buildings in member economies imply immense potential of energy efficiency improvement and carbon emissions reduction. However, it is crucial to adequately recognize and factor in the substantial heterogeneity across member economies in terms of their building stock characteristics, economic development, level of urbanization, building energy efficiency market maturity, endowment of renewable resources, access to finance and technologies, institutional
capacity, policy environment and priorities, among other parameters. This means that the wide range of actions discussed in section IV, by no means, are supposed to be universally relevant and applicable to every member economy. Rather, it is important to tailor policy instruments and actions to country-specific situation, based on a holistic and in-depth assessment on the country’s building sector and the broader energy and climate policy settings in the country.

For example, in South Asian and Southeast Asian subregions where cooling is a critical issue that most countries are facing, the priority is to increase the access to affordable cooling, which is key to the economic and social development objectives of the countries (IEA 2019c). At the same time, it is important to enforce policies to raise MEPS for air-conditioners and also promote building design for improved building envelop thermal performance and reduced cooling demand. For countries in temperate climate zone where heating demand is high during winter, large emissions from the heating infrastructure shall be the main target to address. For example, in Mongolia, heat production and supply is insufficient and inefficient, as a result of aging district heating network with deteriorating performance and large amount of decentralized heating solutions (World Bank 2019). In the PRC, while clean heating in cities and rural areas in the north and sustainable cooling solutions for all types of buildings remain the priorities of mitigation actions in the building sector, large amounts of embodied emissions incurred by building materials production and transportation as a result of the massive construction and demolition activities throughout the country are becoming a hot spot that requires policy interventions from a whole life cycle perspective (Zhou et al. 2022).

Therefore, as a guiding principle, it is necessary to take a differentiated approach to design targeted interventions to support member economies’ ambitions and actions relating to decarbonizing their buildings and construction sector. Where possible, appropriate “grouping” of countries in the same climatic zone and facing highly similar issues and opportunities for their buildings and construction sector could be explored to help deliver the results and achieve the outcome at scale with high effectiveness and efficiency (and potentially lower transaction costs). The overarching objective should be, through extensive upstream engagement with member economies and holistic sector diagnostics, to develop a strong pipeline of sizeable programs and projects with transformative impact on the sectoral decarbonization in member economies.

Based on the above consideration, this note identifies cool roof and heat pump as key building energy efficiency technologies to start with. Cool roof is a “passive” approach that can effectively
reduce the cooling load of a built environment and the resultant use of mechanical ventilation and/or cooling systems, while avoiding the occurrence of overheating and thermal discomfort in summertime and ensuring reasonably good indoor air quality. Applications of cool roof are particularly relevant to member economies located in climate zones that are cooling-dominated or have significant cooling demand during summer, i.e., member economies in Southeast Asia and South Asia (Box 3). For countries in the temperate climate zone, such as the northern PRC, Mongolia, and some member economies in central and west Asia, there exists significant heating demand to be met during winter. To bring down energy and emission intensities of space and water heating and accelerate low-carbon transformation of the building sector in these countries, it is important to promote and scale up the applications of higher-efficiency heating technologies and renewable energy as a clean heat source. **Heat pump** can provide a promising solution.

Both cool roof and heat pump are established technologies suitable for new and existing buildings, with successful real-world applications in Asia, e.g., cool roof in Singapore and Malaysia, and heat pump in the PRC. Compared to many other technologies and design strategies, cool roof and heat pump applications, if properly designed and well operated, can be more cost-effective and technically more straightforward for implementation and replication, thereby providing greater opportunities for interventions at scale.

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**Box 3: Cool Roof Application for Office Buildings in Hyderabad, India**

A demonstration project to quantify and record the benefits of cool roofs was carried out at two office buildings in Hyderabad, India. The study team included the International Institute of Information Technology (IIIT) and Lawrence Berkeley National Laboratory (LBNL), supported by USAID and SPM Thermoshield. The complex for application included two office buildings that were nearly identical. This setup facilitated the investigation by ensuring identical parametric values for floor area, number of floors, roofing material and system, occupancy and schedules, and cooling systems. Each building had two stories, with a roof area of about 700 m². For one building, its roof was painted black. For the other building, a white reflective cool roof coating was applied to its roof.

Weather towers, temperature sensors, current transducers, and data-loggers were deployed to continuously monitor the weather condition (outdoor temperature, relative humidity), building temperatures (heat flux through the roof, surface temperature, roof underside temperature,
Results showed that the application of cool roof reduced the average daily roof surface temperature by 20°C (Figure B2.2) and the cooling energy use by 15%–20% during hot summer days (Figures B3.1 and B3.2).

Figure B3.1: Surface and Under-surface Temperatures of Roof Assembly Before and After Cool Roof Coating Application

Source: Bureau of Energy Efficiency (2017)

Figure B3.2: Heat Flux and Cooling Energy Use Before and After Cool Roof Coating Application

Source: Bureau of Energy Efficiency (2017)

C. Financing Modalities

In general, cool roof, heat pump, and almost all other interventions relating to energy performance of individual buildings are characterized by being of relatively small scale and widely distributed, which incur substantially increased average transaction costs and also put at risk successful implementation and delivery of intended outcome and outputs. Therefore, the "standard" project loan would not be the most appropriate modality in this context.
Sector loan. The sector loan modality can be an appropriate modality for financing a large number of building-level energy efficiency interventions (subprojects) within the building sector of a target member economy. The borrower/executing agency is primarily responsible for identifying, formulating, appraising, approving, and implementing subprojects based on established criteria, whereas ADB's involvement in processing subprojects is normally limited to appraising sample/model subprojects in the initial phase. There is flexibility in terms of replacing subprojects. Compared to the stand-alone "standard" project loan, the sector loan modality may achieve a greater impact on the sector, through an integrated focus on sector policies, development perspectives and plans, and institutional capacity.

Results-based lending. Results-based lending (RBL) is also a potentially appropriate modality, as it allows a large, flexible, and programmatic financing for the target sector with an emphasis on performance and results, e.g., energy saving and emission reductions of buildings. An RBL program can be a sector slice or time slice of a broader, geographically wider, or longer-term government-led program sector program; for example, a program of developing green buildings whose scope is much broader than just energy performance. If well designed, a RBL can be well suited to operations where the government has a strong intent to strengthen incentives and accountability for results under the RBL, and improve institutions and systems to deliver and sustain these results. RBL can also serve as a good platform to channel cofinancing, as it is anchored on the government-led sector program with a common results framework for other development partners involved in the intervention.

Key underlying requirements for using the RBL modality include a favorable and stable policy environment, a sound government-led sector program, government commitment and ownership, strong fiduciary and safeguard systems, and credible and transparent monitoring and evaluation systems. A critical design factor of an RBL program is the clear identification and selection of disbursement-linked indicators (DLIs), which are the basis for disbursing ADB financing. They need to critical result indicators carrying sufficient weight such that disbursement linked to each DLI would be sufficiently large to signal its relative importance and incentivize efforts. The costs for monitoring and verification of DLIs are also an important factor. There have been very few RBL programs in ADB's energy sector operations, with the Electricity Grid Strengthening—
Sumatra Program in Indonesia being the first one.\(^4\) Thus, limited experience and lessons are available as reference.

**Policy-based lending.** In parallel with ADB assistance to project-related investments, a policy-based lending (PBL) can be used to facilitate the implementation of sectoral and intersectoral policy reform programs relating to the transformation of a member economy’s building sector towards green and low-carbon development or, more broadly, multisectoral efforts in climate change mitigation. A PBL can be designed to take a programmatic approach in order to provide more effective and flexible ways of translating complex objectives of structural reforms into implementable policy actions. In this case, a programmatic approach PBL can assist member economies in creating an enabling environment for accelerating and scaling up demand-side energy efficiency, including but not limited to building energy efficiency. Specific support could include (i) improving existing policy and regulatory frameworks; (ii) establishing standards, codes, and specifications; (iii) establishing energy auditing agencies; (iv) strengthening capacity to assess credit risks of intermediaries; (v) deploying adequate financial risk mitigation instruments tailored to these operations; and (vi) developing new business models and incentive mechanisms for end-consumers, utilities, ESCOs, third-party verifiers, and other market participants.

**Multitranche financing facility.** The proposed intervention to building energy efficiency improvement can also be supported by a multilateral financing facility (MFF) modality, which is a flexible financing instrument that provides programmatic assistance to support a medium-term or long-term investment plan of a developing member economy. The overall facility is composed of a series of separate financing tranches (loans, grants, and/or guarantees) over a fixed period. An MFF allowed flexibility in defining the scope, implementation timing, and financing amount of each tranche in line with the member economy government's sector plan and investment targets. It also provides ADB and the government with multiple entry points for policy dialogue based on experience and lessons from an earlier tranche. For building energy efficiency projects which are small and distributed, it would be appropriate to have a geographic design for the MFF, under which similar packages of outputs (energy savings and emission reductions) are delivered in different quantities in different locations across a member economy. It may also be appropriate to have an MFF designed to include the use of financial intermediary lending as its sole focus of the MFF or its certain tranches to support subloans to eligible subborrowers, such as building

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\(^4\) ADB. 2015. *Report and Recommendation of the President to the Board of Directors: Proposed Results-Based Loan to Perusahaan Listrik Negara for the Electricity Grid Strengthening—Sumatra Program (Guaranteed by the Republic of Indonesia).* Manila (Loan 3339-INO).
developers, owners, or ESCOs. The tranches can consist of repeated amounts to the same set of financial intermediaries, or each tranche can lend to different groups of financial intermediaries and subborrowers.

In summary, there would not be a one-size-fits-all solution, and it is necessary to take a differentiated approach based on sectoral policy and regulatory framework, sector development plan/road map, technical and managerial capacities of the sector institutions, availability of technologies and market aggregators, and credit risks of financial intermediaries. The most appropriate modality needs to be determined based on a holistic and in-depth country-specific sector assessment and adequate consultation with government agencies and ADB regional departments (energy/urban divisions and resident missions).
REFERENCES


Delzendeh, E., S. Wu, A. Lee, and Y. Zhou. 2017 The impact of occupants’ behaviours on


Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, IPCC special report Global Warming of 1.5 °C.


