



GlobalABC Regional Roadmap for Buildings and Construction in the Arab Region

2020-2050

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



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Executive summary

Global objectives rely on local implementation. The Paris Agreement codifies the major objectives of the 21st century, namely: “holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change.”¹

Sources like the recent Global Alliance for Buildings and Construction’s (Global ABC’s) Global Status Reports² have highlighted the significant role the buildings and construction sector must play in the decarbonisation of human activities. Strategic objectives like 1.5°C require strategic planning and the successful operationalisation and implementation of such plans. With its Roadmap for Buildings and Construction,³ Global ABC provided comprehensive guidance on how to get from strategy to regional implementation. Based on this guidance, roadmaps for Africa, Asia, and Latin America have been developed.

This report adds a Global ABC Roadmap for the Arab region, covering 22 countries. This wide approach was taken thanks to UAE Ministry of Energy and Infrastructure’s vision to facilitate a step towards the achievement of the decarbonisation of the whole region.

It builds on above mentioned Global ABC roadmaps, tailoring its strategic approach and examples for operationalisation and implementation to the specific context of the Arab region. A distinctive feature of this roadmap is its response to diverse energy-related status quos in the buildings and construction sector across the region and across the eight activities structuring each Global ABC roadmap. Different starting points call for different strategies and focal points. For this reason, guidance in this document is presented like a menu for early starters, moderately advanced, or advanced countries. This means Arab countries can pick the most suitable guidance relative to how advanced they evaluate themselves relative to an activity.

All activities, regardless of the maturity of their implementation, evolve best when being embedded in a framework that enables their further development. For this reason, in this report enablers get special attention in a dedicated chapter, focusing on finance and capacity building. While this framework facilitates stakeholder action in all eight activities, eventually reaching a sustainable buildings and construction sector comes down to sufficient motivation of stakeholders to get on track. While energy savings are typically stressed as the major outcome of energy efficiency measures in the buildings and construction sector, it is the co - benefits of energy efficiency and related energy savings that create tangible added value relative to core human energy needs: affordability of sufficient heating and cooling, job security and creation of new jobs, and more energy security. This is why the analysis in this report concludes with co-benefits related to all eight activities.

¹ United Nations (UN) 2015

² Global Alliance for Buildings and Construction (GABC) and United Nations Environment Programme (UNEP) 2020

³ Global Alliance for Buildings and Construction (GABC) et al. 2020

1. Introduction

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

The buildings and construction sector are responsible for 36% of final energy demand globally, representing 39% of energy- and process-related emissions. Climate scenarios show that emissions in this sector will have to be significantly reduced to achieve the Paris Agreement goals. Furthermore, the 2021 Global Status Report of the Global Alliance for Buildings and Construction (Global ABC) highlights that today's progress on emissions reductions is not on track as energy efficiency improvements are outpaced by floor area and demand growth. To counteract these trends, the global average building energy intensity per unit of floor area would need to be at least 30% lower than 2018 levels by 2030.

1.1 Roadmap objectives

The following are the objectives of the roadmap:

- **Act as a blueprint for the Arab countries to initiate, support, and complement their ambitions to decarbonise the built environment through 2050:** The measures and activities presented in the report should be picked up by the different Arab countries and could support their strategic planning for a decarbonized built environment through 2050.
- **Reflect the diversity of the status of the sustainable and resilient buildings and construction sector throughout the Arab region:** The scales, stages, and priorities in the different Arab countries are highly diverse. Many countries are still in the early stages of integrating energy efficiency and renewable energy in the buildings and construction sector while others have already implemented well-functioning instruments that allow for the transition towards a decarbonised built environment. To respond to this wide range, the roadmap for the Arab region distinguishes the region between early, moderate, and advanced countries. This method is used not to rank the countries but rather to reflect the different stages and offer guidance per activity with proposed steps.
- **Follow the methodology applied in the other regional Global ABC roadmaps to complement the series:** Per the Global ABC regional roadmap methodology, this roadmap focuses on the eight activities that have a major impact on the decarbonisation of the buildings sector. Additional enablers and multiple results are also presented.

2. Methodology

This roadmap is based on the methodology and the definitions of the Global ABC regional roadmap template (Global Alliance for Buildings and Construction (Global ABC) et al. 2020). Some changes were needed to adapt the template to the Arab region context in order to echo the diversity of the Arab region with its different status quos in reaching a better level of energy efficiency in the buildings and construction sector.

2.1 Guiding principles

The regional roadmap for the Arab region is based on the structure and the methodology of the Global ABC Roadmap for Buildings and Construction 2020-2050. Older versions and versions covering other regions (e.g. Africa and Asia) were analysed. The same eight activities were presented in the report with minor deviations based on the context—e.g. new buildings and retrofits were merged due to the use of several equal instruments, but the differences were still highlighted. The definitions of the main activities, their sub-activities, and the definitions related to the three enablers—finance, capacity building, and stakeholder engagement—from the template are used without marking them as a quote.

Some minor deviations took place from the structure of the Global ABC Roadmap for Buildings and Construction 2020-2050:

- To reduce possible redundancy in the thematic areas of finance and capacity building in the Arab region, it was preferred to separate these enablers from the different activities and to summarise them in a specific chapter. The same separation is applied for the multiple benefits as outcomes as well.
- To adapt the Global ABC activities to the Arab region context, some sub-activities were omitted, added from different Global ABC versions, or merged. The detailed comparison to the latest Global ABC Roadmap for Buildings and Construction 2020-2050 is listed in Chapter 9 (Annex).

To reflect the diversity of the Arab region (e.g. various climatic, economic, demographic, energy emissions, and urbanisation patterns), an additional chapter on the status quo is included. The countries were mapped into advanced, moderate, and early starter countries. The indicators used were classified into three categories: general socio-economic, high-level sustainability, and energy efficient buildings. The detailed process and methodology of clustering is discussed in Chapter 3.

The clusters do not comprehensively represent the detailed status of a country; they serve as a tool to group the countries for the roadmap development (i.e. some countries among the early starters or moderate groups could be excelling at specific fields more than others of the advanced cluster). This exercise aimed to reflect the diversity of the region in terms of different development phases and not to rank the different countries.

The baselines created through the clustering process were followed by focused data collection for the three mentioned countries.

2.2 Data collection

After selecting the countries representing each cluster, focused data collection was initiated (see Figure 1). A first round of screening of available international literature related to the building sector and energy efficiency was conducted. This was conducted to set common understandings through a preliminary literature review of the topic (e.g. international

decarbonising strategies, net-zero energy buildings, and the different template versions and regional Global ABC roadmaps).

The second phase included focused data collection for the selected countries. This phase depended on desk-based research. An assessment list with all the sub-activities was created describing the status of the sub-activity depending on common key performance indicators (KPIs). The assessment list included the different sources used, including: building codes, regulations, standards, reports/grey literature, internet documents, and public and private initiatives in the country. Any missing data was covered through interviews with experts from the studied country.

An iterative process took place during meetings with the client, the Regional Center for Renewable Energy and Energy Efficiency (RCREEE) team (partner team), and the internal Guidehouse team. A group of subject matter experts was responsible for the adaptation process of the sub-activities to the Arab region context as well as the detailed formulation of the various roadmaps.

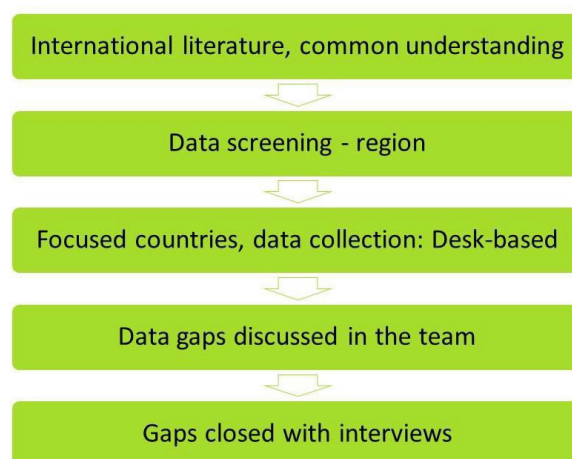


Figure 1. Main working steps of the data collection process.

2.3 How to use the regional roadmap document

This section describes how to read the document and how to interpret the targets. The core of this report is Chapter 4, Description of activities, which identifies common goals and targets for key actions across the eight activities. These suggestions are not intended to be prescriptive; rather, they are provided to act as guidance to governments seeking to draft their own action plans. Each activity represents a segment of the buildings and construction sector: urban planning, new buildings, existing buildings, building operations, appliances and systems, materials, resilience, and clean energy. Each of these represents a key ingredient of how buildings influence our environment and vice versa.

- **Activity 1: Urban planning.** This activity covers land use, zoning, and other planning associated with how buildings, transport, and energy systems interact.
- **Activity 2: New buildings.** This activity covers all aspects of new buildings, including the design process, design strategies, codes, and labels.
- **Activity 3: Existing buildings.** This activity covers all aspects of the improvements of existing buildings.

- **Activity 4: Building operations.** This activity covers all aspects of building operations and management.
- **Activity 5: Appliances and systems.** This activity covers lighting, appliance, and equipment systems that are used in new and existing buildings.
- **Activity 6: Materials.** This activity covers envelope, structural, and product materials used in buildings.
- **Activity 7: Resilience.** This activity covers all aspects of building resilience that enables increased capacity to adapt to and mitigate the effects of changing climates and other natural disasters.
- **Activity 8: Clean energy.** This activity covers the clean energy transition away from carbon-intensive fuels to renewable energy resources.

Each of the activities is structured similarly, illustrated by relevant examples, and can be read in isolation or conjunction with the other parts of the document. Each of the activities covers the following:

- **Key actions:** Summarizes key actions identified for the activity.
- **Stakeholders:** Maps the different stakeholders relevant to the activity and their relative importance.
- **Policy and technology actions**, which follow a consistent structure as well:
 - Definition: Based on the Global ABC template, The definitions of the actions from the Global ABC template are included in each section, allowing the reader to get a clear idea of the captured elements of the specific action.
 - Describing sub-roadmap: This abstract should give a high-level idea of the possible working steps needed to accomplish the relevant action. The policy cycle approach was used for the policy actions and partly for the technology section. A key component of the policy cycle is to have a cyclical process that achieves continuous improvement in the performance of the policies to support the transition to low-emission, efficient, and resilient buildings, with the following main steps:
 - Preparatory steps
 - Strategy and conception
 - Instruments
 - Implementation
 - Monitoring
 - Evaluation / Reiteration
 - For specific technology sub-roadmaps, the following logic (market transformation) was applied to structure the working steps:
 - Demonstration (initiate)
 - Pre-commercial (knowledge sharing)
 - Supported commercial (practice)
 - Mainstream (upscale)

- Describing the status quo of tier groups: The current situation for the three development phases (early, moderate, advanced) are described.
- Next steps: The short-term actions are listed per development phase; ideally these actions should be accomplished before 2030.
- Sub-conclusion: A figure summarises the essential steps of the policy or technology activities to accomplish decarbonisation.

The policy activities are expected to be performed as short-term measures—roughly 5 to 10 years should be planned; depending on the country situation, this time period could be shorter. The illustrated cycle is expected to be recurring to tackle the different policy sub-activities and reiterative if the targets were not met.

The targets of the technology activities were quantified assuming the following scenario:

- Advanced countries should meet their net-zero targets by 2050.
- Targets might vary for the moderate and early starters as they have still many sub-activities untapped; it is assumed they will need more time to achieve a net-zero target.

Each activity chapter ends with two regional or international **best practice** examples, showcasing implemented projects or strategies. Following the description of the activities in Chapter 4, Chapters 5-7 illustrate necessary enablers, the possible benefits relevant for a decarbonised buildings and construction sector, and guiding principles for a roadmap formulation.

- Enablers: These enablers are necessary “ingredients” to boost a sustainable and resilient built environment. Chapter 5 presents exemplary instruments of financial tools, capacity building, and stakeholder engagement.
- Multiple benefits: The implementation of energy efficiency, resource efficiency, and renewable energy measures in the buildings and construction sector does not only reduce energy demand and greenhouse gas (GHG) emission, it can also generate tremendous relevant co-benefits. A selection of these benefits is shown in Chapter 6.
- Guiding principles: Chapter 7: Guiding principles for setting up roadmaps explains the essential elements for formulating a roadmap using the PESTLE (Political, Economic, Sociological, Technological, Legal, and Environmental) method.

The report ends with a conclusion and outlook chapter, reflecting the main purposes and ideas formulated in this roadmap.

3. Arab countries overview

This Roadmap focuses on the Arab countries, which includes 22 countries: Algeria, Bahrain, Comoros, Djibouti Development, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Palestine, Qatar, Saudi Arabia, SomaliaDevelopment, Syria, Tunisia Development, and Yemen. The Arab countries are spread over North Africa, partially sub-Sahara, and southwest Asia.

Most of the Arab countries are members of international conventions to combat climate change. For example, all Arab countries are members of the Montreal Protocol, and most of them have ratified its amendments. In 2015, in Sendai City, Japan, the 22 member states of the Arab League Member States signed the Sendai Framework for Disaster Risk Reduction 2015-2030 that aims to outline clear targets to be achieved in 2030; these targets are related to: (i) awareness of climate disasters, (ii) strengthening and managing the disaster risks, (iii) promote climate mitigation and adaptation related investments, (iv) develop plans and implement actions for the recovery, rehabilitation and reconstruction of post- and pre- disaster communities, that is known as the Build Back Better (BBB)⁴.

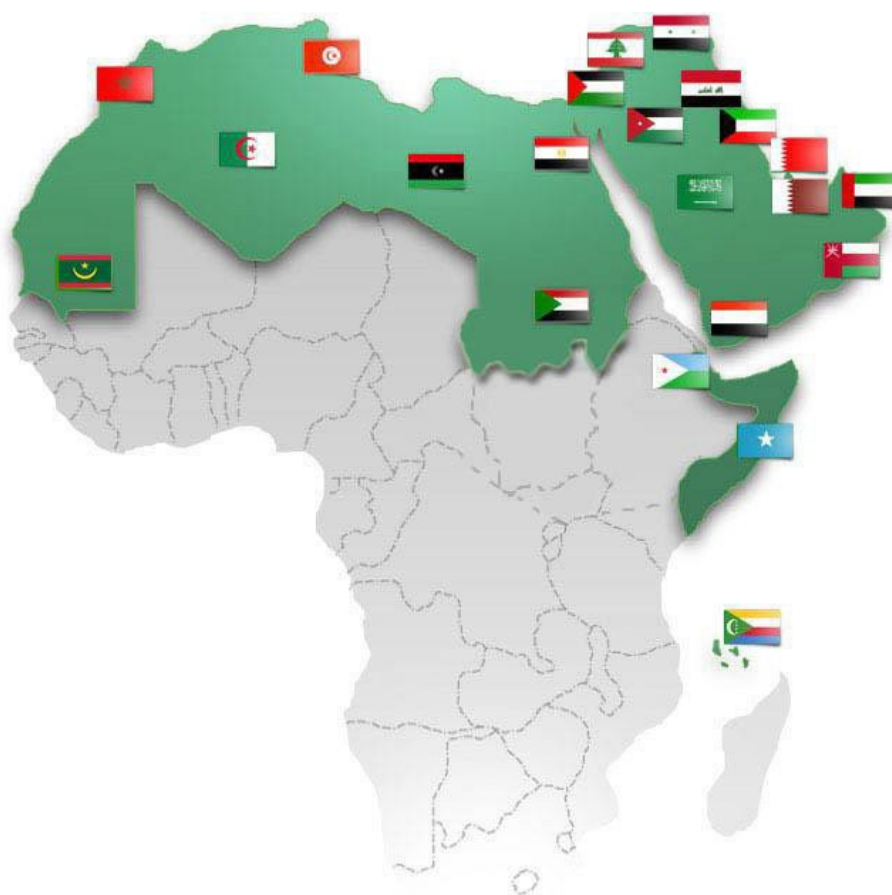


Figure 2. Map of Arab countries (League of Arab States , 2022)

Disclaimer: Country borders or names do not reflect the official position of the United Arab Emirates

⁴ For more information about the BBB Framework, visit its website: <https://buildbackbetter.co.nz/about-us/>.

3.1 The necessity of decarbonise the buildings and construction sector in Arab countries

The buildings sector is a major source of energy consumption and a main contributor to the generated GHG emissions in Arab countries. The continuous population and economic growth, improved standard of living, and rising urbanisation trends are increasing the demand on the energy required for the buildings sector, which in the Arab countries has so far been met predominantly by non-renewable energy sources.

Therefore, decarbonising the buildings sector became of great importance because of the associated environmental benefits and the great business and economic opportunity that decarbonisation provides in emerging markets—an estimated value of USD 25 trillion by 2030 (IFC, 2022). The following points explain the key drivers for the necessity of a decarbonised building sector in the Arab Region.

3.1.1 Unprecedented levels of construction growth

With annual population growth of around 1.9% (World Bank, 2019), the population of the Arab countries is expected to dramatically grow to beyond 720 million by 2050; Iraq, Development, and Palestine are expected to double their population between 2015 and 2050 (UNICEF, 2019). To cope with the enormous demand on housing, the construction sector is growing the Middle East and North Africa (MENA) Region. Despite the slowdown of construction in some countries caused by restrictions from the COVID-19 pandemic and economic crisis in 2020 and 2021, construction rates have been growing over the last two decades. The construction rate in MENA region is expected to grow by 4.1% in 2022 (Constructiondigital, 2022). The large-scale projects in and developments across the region have raised the construction growth rates to between 4% and 9% in the UAE, Saudi Arabia, and Egypt. New and existing buildings play a substantial role in future buildings-related energy consumption and emissions, as the long life of buildings can endanger the transition to low-carbon development.

3.1.2 High energy-saving potential in the buildings sector

Based on the analysis and studies of the United Nations Economic and Social Commission for Western Asia (UN ESCWA) (UN ESCWA, 2018), it has been proven that the implementation of energy efficiency measures at the national level will result in economic benefits. The buildings and construction sector in Arab Countries had a 30% share of the total primary energy supplies (TPES) and 23% of the total final energy consumption (TFEC) in 2019, with an average annual growth rate of 4% from the base year 1990. If the Arab Region would strictly adopt minimum energy performance standards (MEPS) and building energy efficiency codes (BEECs), this would result in 5% reduction in the total final energy consumption (TFEC) by 2030, and if the net-zero building codes are applied by 2030, this would result in 16% reduction in total final energy consumption (TFEC) by 2050. Large scale retrofits could also result in a 30% reduction of the total final energy consumption (TFEC) by 2050.

3.1.3 Utilization of the abundant renewable energy sources

The Arab region enjoys a high potential of renewable energy, particularly solar applications of renewable energy because the Arab countries are located in or near the SunBelt. Renewable energy deployment is evolving rapidly, and several countries are significantly implementing National Renewable Energy Action Plans (NREAPs) and pledging high ambitions in their nationally determined contributions (NDCs) (IRENA, RCREEE, 2016). Countries such as

Egypt, Jordan, Tunisia, and Morocco as well as most Gulf Cooperation Council (GCC) countries have developed policies for renewable energy integration in buildings. The penetration of renewable energy in the buildings sector has not yet reached satisfactory levels of utilization. Solar energy applications at the building scale such as photovoltaics (PV) and solar water heaters can achieve financial advantages for households and provide environmental and economic benefits at the national level.

3.1.4 Reduce climate stress and building resilience

Most of those countries face different sets of similar and heterogenous climate change challenges. The Arab region is vulnerable to the negative impacts of climate change with several consequences such as high temperatures, threats to coastal area, increased drought and desertification, scarcity of water resources, and increased salinity of the groundwater. Based on the Regional Assessment Report (RAR) on disaster risk reduction in the Arab Region issued by the UN Office for Disaster Risk Reduction (UNDRR) in 2021, the total cost of damages associated with the largest 10 disasters in the Arab region is nearly \$22.3 billion (UNDRR, 2021) (see [Figure 3](#)).

Climate-related hazards became frequent and intensified, especially with the unsupervised consumption of natural resources and the increasing production patterns of energy from conventional resources. The Arab region's economic development might be associated with hyperconnected and rapidly increasing climate risks such as droughts, urbanisation of greenfield lands because of internal displacement, and migration plans of communities.

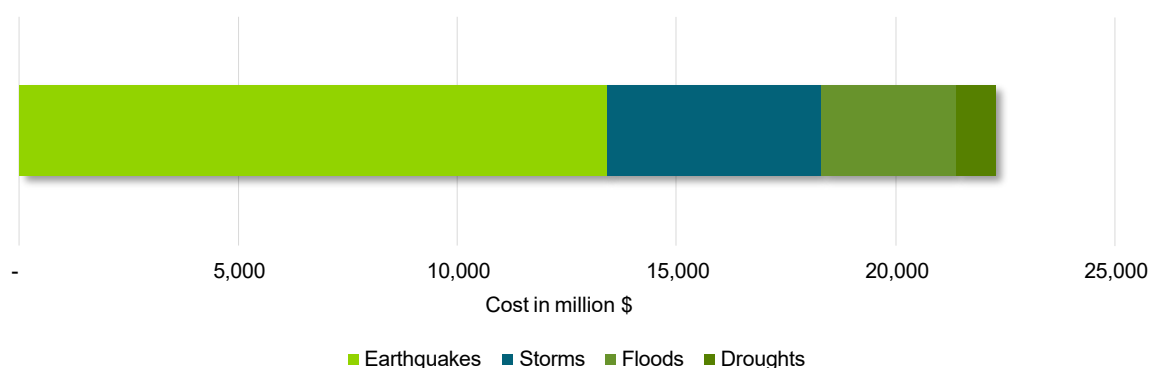


Figure 3. Damage costs associated with the largest climate disasters in the Arab region.

3.2 Background information on the Arab region

3.2.1 Demographic urbanisation rates in Arab countries

In 2020, according to World Bank Data, the Arab Countries population reached around 436 million people, with 1.91% of annual growth. Egypt is the most populous country with more than 103 million in 2021. Yemen, Saudi Arabia, Morocco, Iraq, Algeria, and Sudan have a population between 30 and 40 million. Interestingly, the countries with the highest population have a higher average annual growth of around 2%. Around one-third of the population is considered young (aged between 15 and 29). Furthermore, this young population is the fastest-growing segment, making the Arab region among the most youthful regions in the world, with a median age of 22 years compared to a global average of 28. (YOUTH Policy, 2022) (Mirkin & UNDP, 2010).

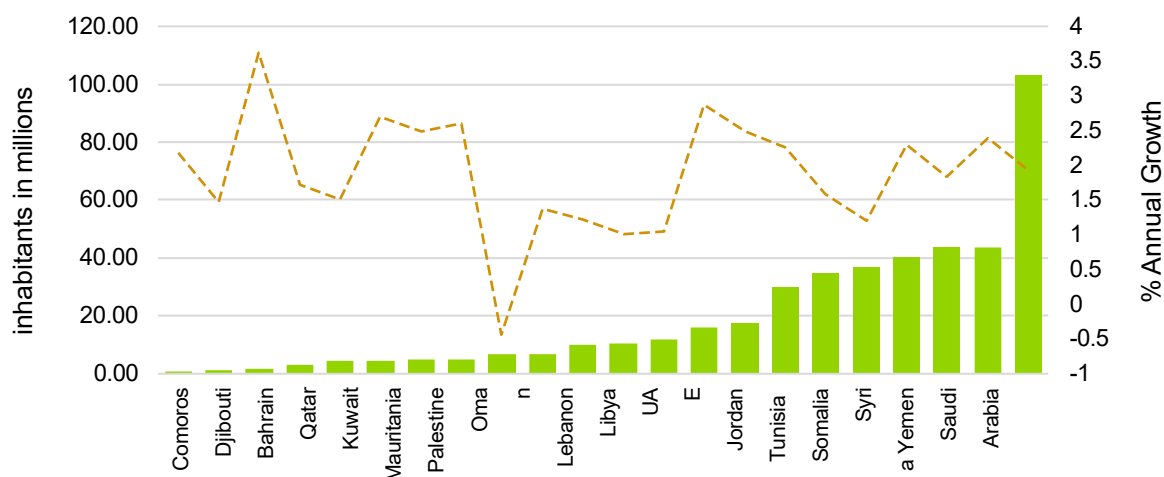


Figure 4. Population in Arab countries. The yellow line represents the percentage of annual growth (World Population Review, 2022).

The world is becoming more urbanised with around half of the world's population living in urban areas. This phenomenon has different impacts across regions and countries. In comparison with Europe and Latin America, Africa and Asia are still generally rural and will urbanise faster than other regions over the coming decades (United Nations, 2018). Urbanisation describes the process by which large numbers of people leave the countryside to move into cities (Cambridge Dictionary, 2022). The degree of urbanisation of a country might be described by two factors: the first is Percentage of urban population, rate of urbanisation, which reflects the rate of change of the size and percentage of the urban population over a given period. The urban population percentages of the Arab countries are shown in Figure 5, while the rate of urbanisation is shown in Figure 6. The Arab countries are not uniform in terms of urban population percentage. Most Arab countries have an urban population of more than 50%. Interestingly Development (the country with the highest population) has an urban population of a little above 40%.

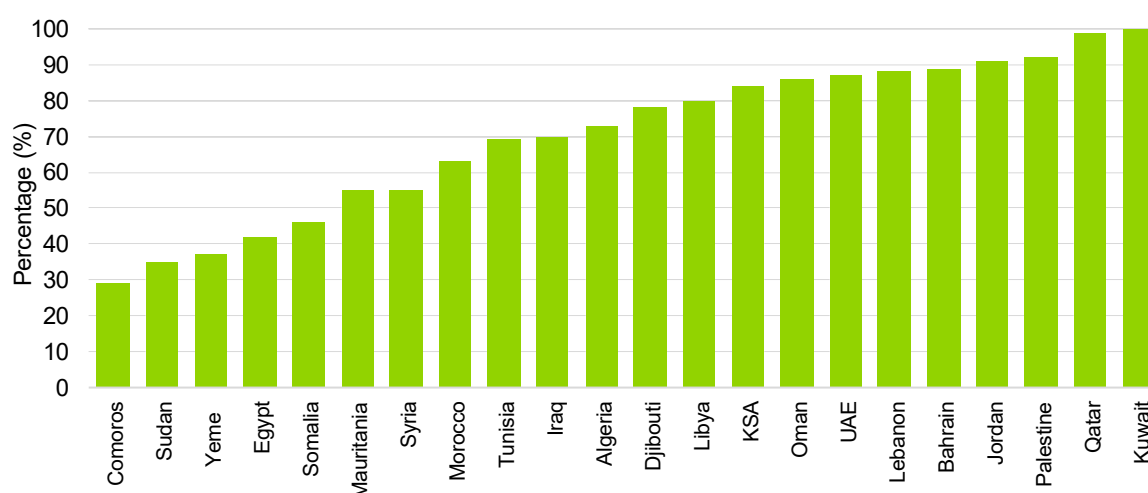


Figure 5. Urban population percentage of the Arab countries (World Population Review, 2022).

The Middle East has the youngest population of any region in the world and the second highest rate of urbanisation, which ranges between 2% and 5%. With an urban population of around 260 million (The World Bank Data, 2020) and an average urban population growth of around

2.4%, these trends are changing the landscape of cities and the settlement in Arab countries, which has significant implications on housing demands, living conditions, infrastructure, and the building sector in general.

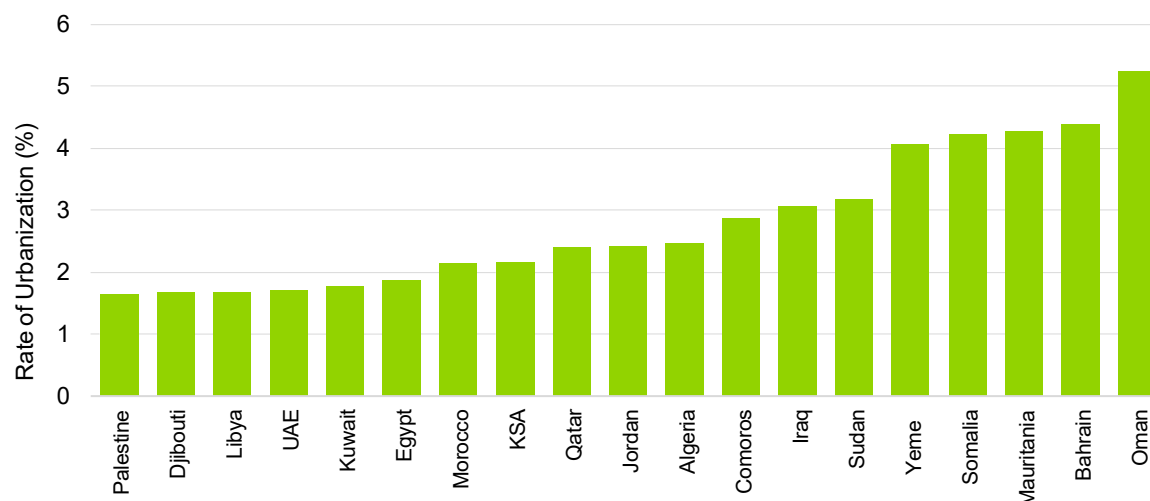


Figure 6. Rate of urbanisation in Arab countries (World Population Review, 2022).

3.2.2 Climate zones

The countries of the Arab region have a diverse climate pattern, but some regional trends and characteristics are similar across the Arab countries. Most of those countries have a hot and dry climate with arid and Mediterranean semi-arid areas. Precipitation is typically low in the Arab countries; therefore, the region is generally known for its hot and arid climate conditions (Climate Center , 2022). Zooming in the region on the world climate zones as shown in Figure 7 shows the Arab Countries are categorised by the world climate zones:

- Extremely hot dry (0B)
- Very hot dry (1B)
- Hot dry (2B)
- Warm dry (3B)

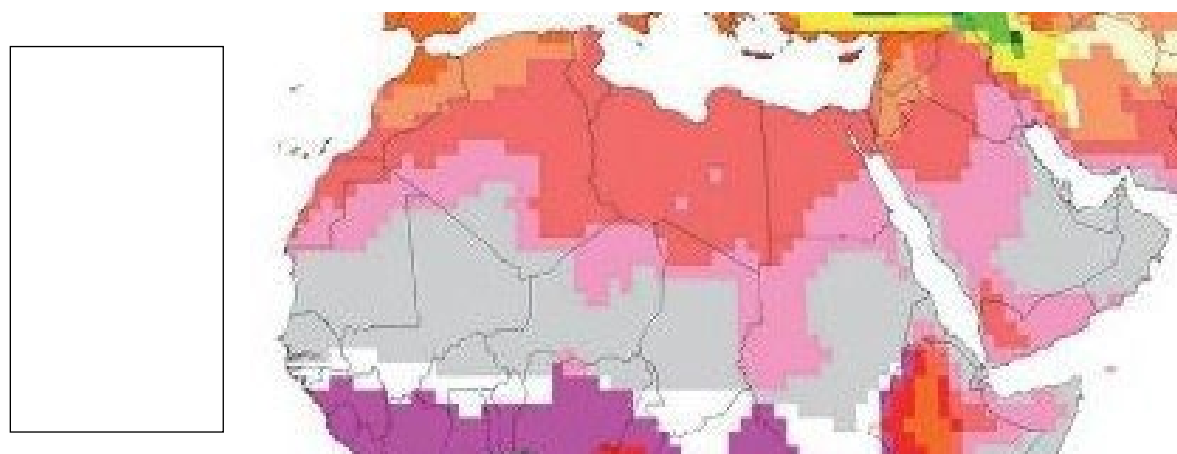


Figure 7. Climate zones of the Arab Countries (ASHRAE Standard 90.1, 2016).

Such hot climates lead to a high number of cooling degree days (CDDs). Based on hourly climate data, (Krarti & Pyeongchan, 2016) prepared contour maps of the annual heating degree days (HDDs) and CDDs. As the following figures show, HDD values of cities located close to the Mediterranean region are higher in comparison with cities located near the deserts where the CDDs have higher values with significant energy demand to space cooling (UN ESCWA, 2018) (UNDRR, 2019).

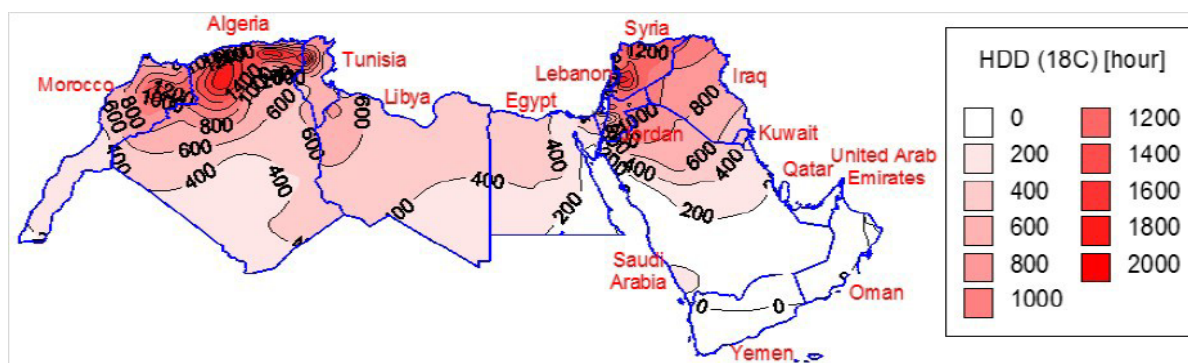


Figure 8. Annual HDDs in Arab countries (Krarti & Pyeongchan, 2016).

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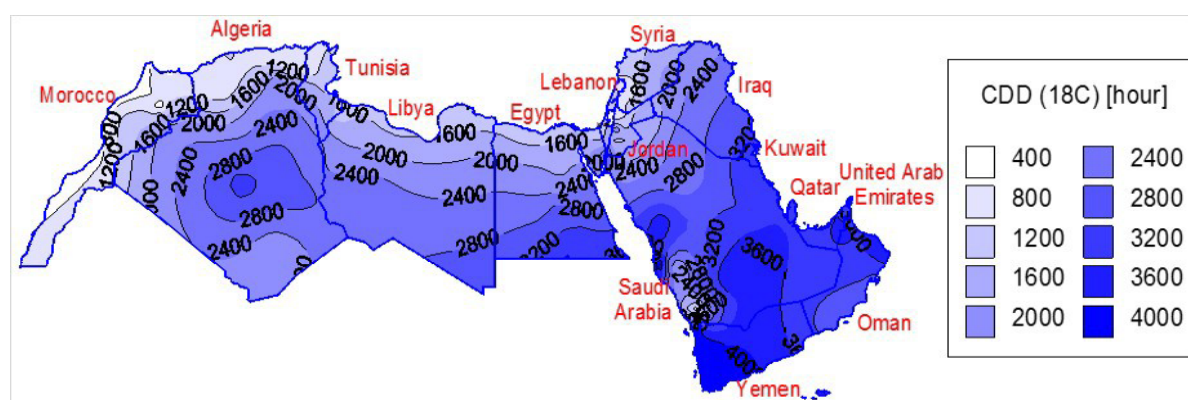


Figure 9. Annual CDDs in Arab countries (Krarti & Pyeongchan, 2016).

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3.2.3 GDP in Arab Countries

Gross domestic product (GDP) per capita, purchasing power parities (PPP) can be used as an indicator of the relative standard of living of the inhabitants of each country. It can also indicate the purchasing power of households and possibly their capability to spend on energy efficiency measures (Eurostat, 2022). Looking at the GDP per capita, PPP for the Arab countries, there is a huge variation in income (see Figure 10). Countries of the GCC (Bahrain, Kuwait, Qatar, Saudi Arabia, and UAE) have the highest GDP per capita—at least double the average of all Arab Countries. Other countries (Egypt, Lebanon, Algeria, Tunisia, Jordan, Iraq, and Morocco) have an income comparable to the average of the Arab Countries. The lowest national income is found in the sub-Saharan countries (Somalia, Comoros Development, and Mauritania) and in countries with unusual local circumstances (Syria, Palestine, and Yemen).

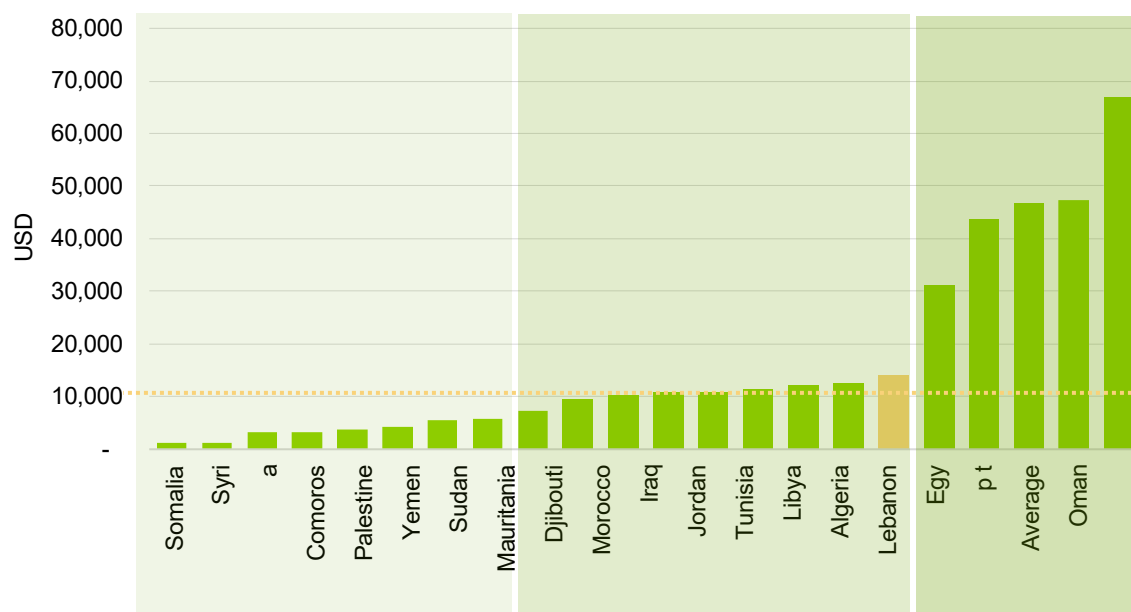


Figure 10. GDP per capita, PPP in the Arab countries (The World Bank Data , 2020).

3.2.4 Energy and emissions

Oil and petroleum products are the leading energy commodity among all energy types worldwide, followed by natural gas. It is anticipated that these two commodities will continue to lead over the upcoming years but with declining shares. The Arab Region itself relies on oil and petroleum products to supply its energy needs and to power its economic activities: 56% of the total primary energy supply (TPES) is from oil and natural gas compared to 38%.

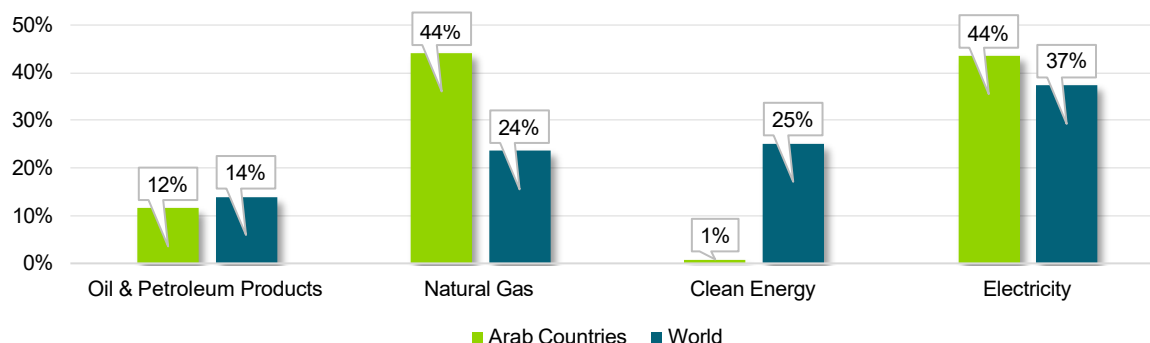


Figure 11. Breakdown of energy commodity shares by the buildings and construction sector (IEA Statistics, 2019).

As

Figure 11 shows, the Arab Region is mainly consuming fossil fuels. The region contains some countries that are among the largest exporters globally. In contrast, clean energy sources (bioenergy, hydro power, nuclear, and renewables) are prominent in other regions, constituting of 25% of the worldwide total primary energy supply (TPES). Several countries in the Arab region have taken necessary steps to roll out clean energy generation technologies in their energy mix and have put ambitious plans to increase the shares of renewable energy technologies, especially solar PV and large-scale wind energy. As Figure 12 shows, the total final energy consumption (TFEC) of the Arab Region had reached nearly 5,567 TWh in 2019 with an annual average growth rate of approximately 4%, while the consumption in 2019 had almost tripled compared to the base year 1990.

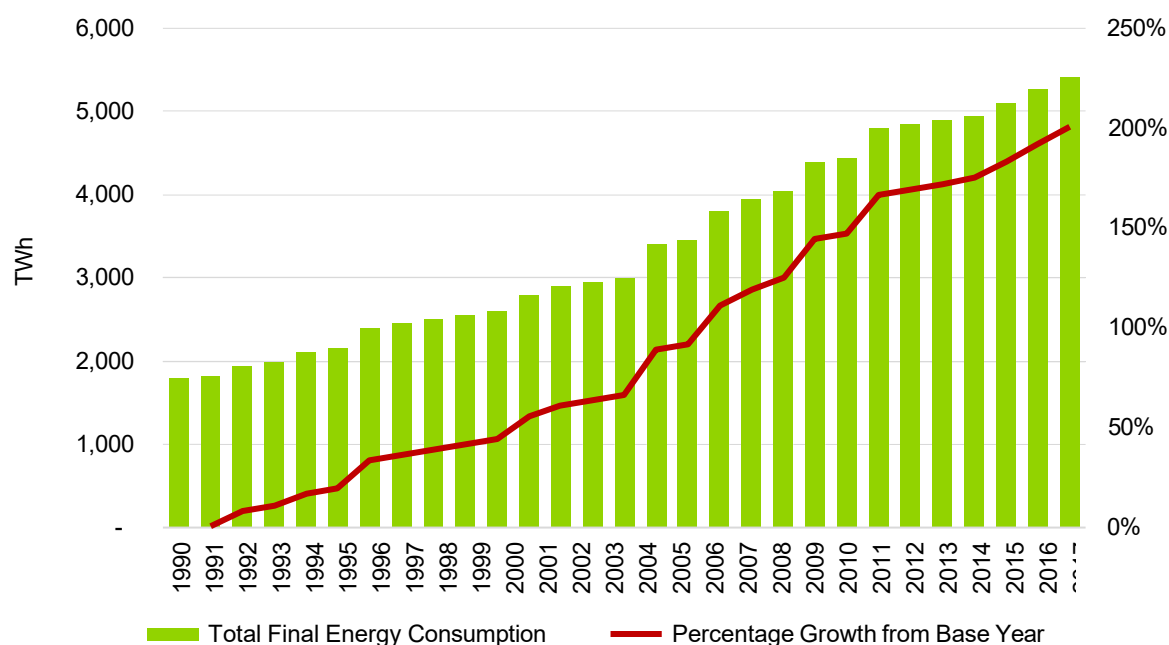


Figure 12. Arab region's TFE and growth rate (UN ESCWA, 2018).

Figure 13 shows the breakdown of the total final energy consumption (TFEC) by sector in the Arab Region. Most of the energy in the Arab Region is consumed by the industry (29%) and transport (28%) sectors, followed by the buildings sector, which consumes 27%. Therefore, any considerable improvement of the energy performance and energy efficiency of buildings will lead to a significant tangible result.

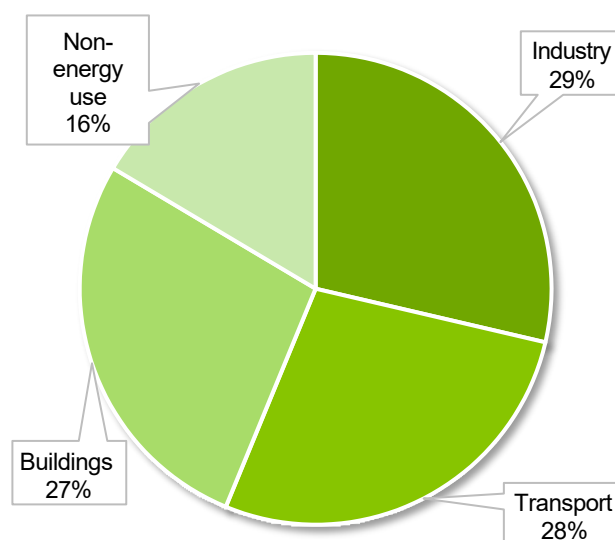


Figure 13. Sectoral breakdown of the TFE in the Arab world (UN ESCWA, 2018).

Based on the data collected by the World Bank (World Bank Data , 2018), the carbon emissions per capita strongly vary across the Arab Countries. It can be as low as 0.31 tCO₂eq/capita in Comoros and as high as 32 tCO₂eq/capita in Qatar. Figure 14 shows the CO₂ emissions (metric tons per capita) in the Arab Countries

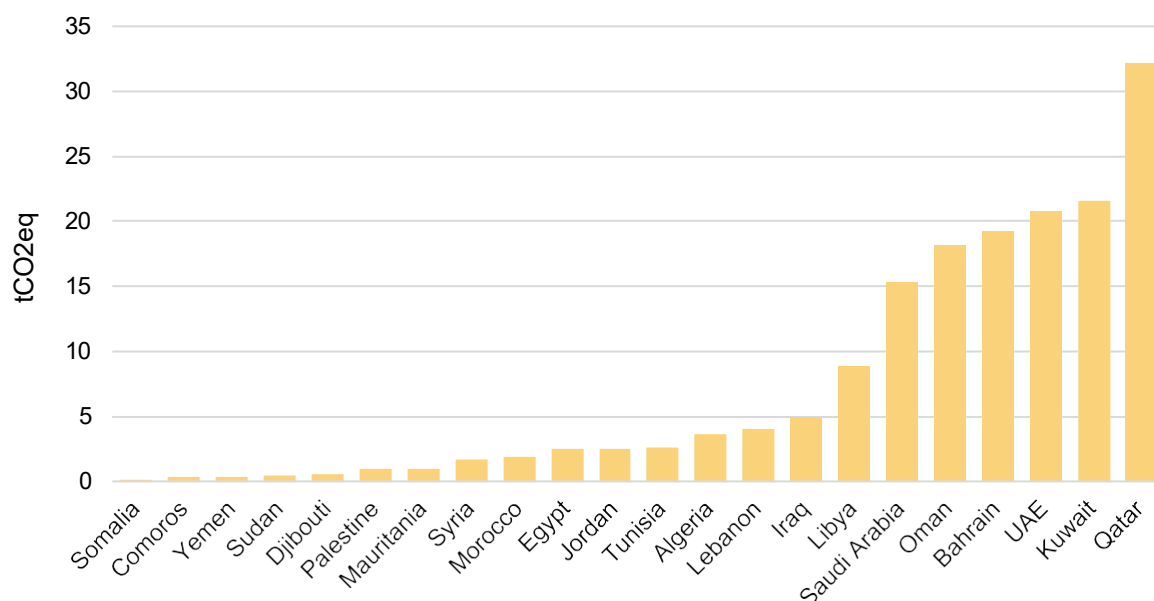


Figure 14. Emissions per capita in the Arab countries (World Bank Data , 2018).

3.2.5 Policy landscape of energy efficiency, uneven levels of implementation

Most of the Arab Countries have adopted and implemented policy instruments governing energy efficiency in the buildings sector. Those policy instruments cover a wide range of strategies, plans, laws, codes, and standards. For example, most of the Arab countries have submitted their National Determined Contributions (NDCs) and have elaborated their National Energy Efficiency Action Plans (NEEAPs). In NDCs and NEEAPs, the buildings sector is directly and indirectly impacted by a set of actions and measures. Most of the Arab countries have established governmental entities to supervise and promote energy efficiency in the buildings sector, established EEBCs, or added energy efficiency provisions in the general building codes. While those EEBCs are technically well elaborated and covering all building components, they are achieving uneven levels of success in terms of implementation and enforcement.

3.3 Current situation: differences across Arab Countries

As discussed previously, there are large disparities across the Arab countries in terms of demography, economy, energy intensity, GHG emissions, and policies governing the buildings sector. Additionally, there are uneven levels of development and implementation of policy instruments. Those disparities and variations can be seen in terms of the indicators covering the Global Alliance for Buildings and Construction (Global ABC) Roadmap. Those indicators may include but are not limited to policies for sustainable building including availability and enforceability of national policies for efficient buildings, implementing entities, existing building codes, national energy plans, relevant policies that encourage using efficient appliances as well as the availability of financing mechanisms for building. To develop the roadmap while reflecting those disparities, it was important to investigate the status of different sets of indicators and criteria to describe the policy instruments and their level of implementation in the Arab countries.



Figure 15. Steps to develop the roadmap for Arab countries

3.3.1 Indicators describing the policies governing the construction buildings sector

The Guidehouse team investigated the progress achieved by countries by studying different indicators to evaluate the variations between countries in the sustainable and energy efficient buildings sector. The team conducted a mapping exercise based on specific indicators covering the energy efficiency policies, related regulatory frameworks, and relevant practices in each country and whether those policies are mandatory or not and their levels of implementing and enforcement. The following list shows the specific indicators used to assess each country's progress:

- Policies for efficient and sustainable buildings sector: Any policies aimed to low-emission, efficient, and resilient buildings by enabling a local environment that has sustainable resources.
- Dedicated entity for energy efficiency measures and sustainable buildings: Refers to the existence of dedicated bodies responsible for setting the policies and strategies and implementing energy-related measures in buildings sector.
- Electricity and oil tariff reforms: A policy or a plan to remove the subsidy of electricity tariff.
- Sustainable buildings codes: The existence of a code that includes requirements for increasing the environmental performance and energy efficiency in buildings.
- MEPS and labels for appliances: Any policies aimed at setting a minimum requirement for energy performance that appliances must meet or exceed before entering the market for commercial purposes.
- National plan for clean energy and sustainable buildings: The existence of NREAPs and NEEAPs that include measures aimed at optimising the energy consumption in the buildings sector.
- Commitment for carbon emissions reductions: Indicates if there are NDCs adopted by the countries, or any measures aimed at reducing carbon emissions in buildings.
- Financing energy efficiency measures in buildings: Availability of financial mechanisms to incentivise the construction of efficient buildings.

The mapping exercise relied on the expertise of the author teams, knowledge gathered from other projects and studies, data and resources of the national entities in the Arab countries,

and reports published by international agencies. Additionally, dedicated expert interviews with national and local experts have been conducted to draw a clearer picture about the status of enforcement and implementation of those indicators, policies, and regulatory frameworks.

3.3.2 Results: different development phases

Based on the above-mentioned indicators, the countries were clustered into three groups:

- Early development countries
- Moderate progress countries
- Advanced progress countries

The early development countries category refers to countries that have limited policies or strategies, dedicated entities, or financial mechanisms that aim to promote the sustainable buildings sector. The moderate progress countries are those that have good progress in terms of policies and in the implementation and enforcement of those policies. The advanced progress countries category indicates these countries are giving higher priority to the energy efficiency in buildings and have achieved good progress towards sustainable buildings and cities.

The below table to be used for self-assessment, allowing each country to position itself in one of the three clusters. Countries collecting less than 5 points are considered to be in the early development category, countries collecting between 5 and 10 points are considering to be in the moderate progress category and countries collecting more than 10 points are considered in the advanced progress category.

Table 1 – Self assessment Tool

Efficient Buildings Indicators	0	1	2	Max Achievable	Score
Policies for sustainable buildings/cities.	Do Not Exist	Exist	NA	1	
					0
Dedicated Entity for Energy Efficiency	Do Not Exist	Exist	Exist for Building	2	
					0
Electricity Tariff/Oil Prices Reform plans.	Do Not Exist	Exist	NA	1	
					0
Sustainable Buildings Codes.	Do Not Exist	Exist	Enforced / Mandatory	2	
					0
MEPS & Labels for Efficient Appliances.	Do Not Exist	Exist	Enforced / Mandatory	2	
					0
National Plan for Clean Energy Systems.	Do Not Exist	Exist	Exist for Building	2	
					0
NDC commitment to Carbon Emissions Reductions.	Do Not Exist	Exist	Announced Target	2	
					0

Funding for Sustainable Projects	Do Not Exist	Exist	Exist for Building	2	
					0

3.3.3 Conclusions for the roadmap in Arab Countries

The Arab region is vulnerable to the negative impacts of climate change such as the high temperatures, threats to coastal area, increased drought and desertification, scarcity of water resources, and the increased salinity of groundwater. The unprecedented levels of construction and population growth, the rapid urbanisation rates, and the high burden of energy bills at the national and household levels are among the reasons that make decarbonising the buildings sector a necessity in the Arab countries.

While the Arab countries face comparable challenges towards decarbonisation, there is a lot of variation and disparities in terms of the local circumstances in each country. Those disparities vary between size of population, economy, energy intensity, and the country's capabilities to move towards sustainability. Moreover, there are uneven levels of development and implementation of energy efficiency policy instruments in the buildings sector. Consequently, there is a need to differentiate and cluster the countries based on all this criteria and local circumstances. This has been prepared in a format of mapping exercise based on specific set of indicators and criteria.

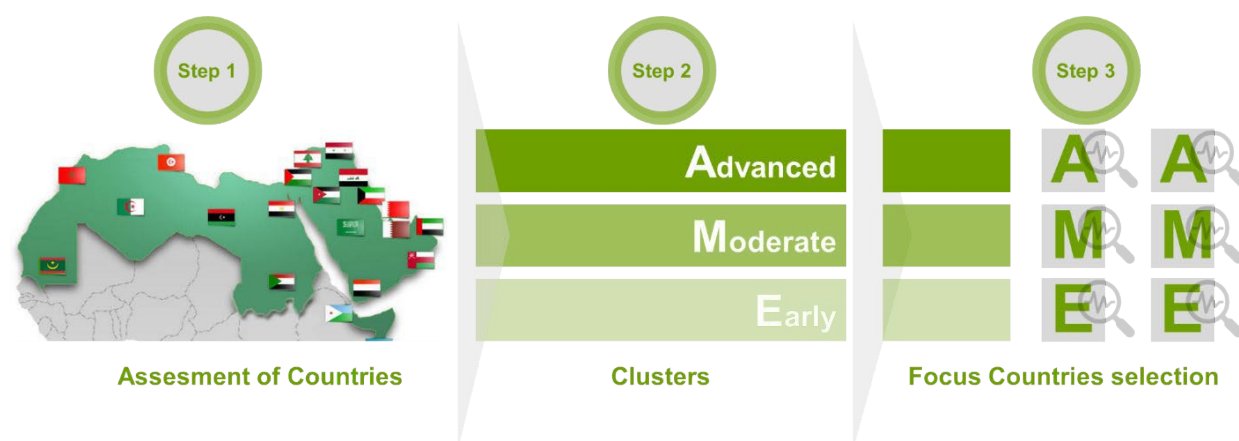


Figure 16. Mapping of countries into groups.

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The mapping exercise defined three groups of countries as advanced, moderate, and early development. Based on that, this roadmap provides a general roadmap and then specific steps for each group of countries using the methodology described in chapter 2.3.

4. Description of activities

This chapter describes eight activities based on the Global ABC regional roadmap template. Each activity is a crucial element to decarbonise the construction sector of the Arab region. Arab countries could use the following descriptions as a foundation to create their own roadmap, adding new elements to their adapted country version. Because this should be a living document, the measures and observations are not exclusive and could be amended with new developments soon.

4.1 Activity 1: Urban planning

The form, compactness, and colour of buildings, as well as mutual shading, have a great influence on energy demand in buildings and renewable energy capacity. They are framed by rules set in urban planning policies. Their impact on energy consumption and local energy production should be taken into consideration when defining urban planning policies and urban development projects (e.g. new urban districts or rezoning).

In the coming decades, with an increasing link between urban planning and its impact on energy use and emissions from buildings and transport, urban planning policies can support the transition towards low-emission, efficient and resilient buildings, and construction. In the following section, the top three actions are presented for each development phase.

4.1.1 Key actions for urban planning

Key actions to enable sustainable urban planning in early starter countries:

- Increase integrated urban development based on local background and needs. Coordinate preparatory steps in terms of political will and stakeholder mapping.
- Expand urban and territorial planning policies and structures. Establish a land registration system and information databases to register land use and ownership, environmental resources, and disaster risks.
- Facilitate spatial planning and vertical integration. Prepare principles of subsidiarity and multi-level governance. Introduce multiscale structure of territorial and urban planning.

Key actions to enable sustainable urban planning in moderate countries:

- Increase integrated urban development based on local background and needs. Scale-up integrated planning approach and strategy to the whole country. Follow-up on trainings and capacity building of urban planners and other stakeholders.
- Expand urban and territorial planning policies and structures. Generate a sustainable planning concept and implementation strategy for new and existing areas.
- Facilitate spatial planning and vertical integration. Introduce space planning principles and regulations. Increase multi-level governance approaches.

Key actions to enable sustainable urban planning in advanced countries:

- Increase integrated urban development based on local background and needs. Enhance the planning process and translate voluntary recommendations into mandatory requirements.
- Expand urban and territorial planning policies and structures. Establish a country-wide system of processes and regulations that provide a solid long-term legal framework for land use planning.
- Facilitate spatial planning and vertical integration. Create overall spatial planning policies and regulation for the whole country. Set achievable targets along suitable timelines and assess performance and transparency of multi-level processes.

4.1.2 Stakeholders for urban planning

In the Arab region, the key stakeholders for sustainable urban planning include those that can influence urban planning and those that can deliver the results of low-emission, efficient, and resilient buildings through urban planning. Additional stakeholders include those that can support the process through research, funding, training, and making technologies available. All these stakeholders are essential to delivering on roadmap targets. Table 2 shows the stakeholders; the darker the colour of the cell, the more relevant the stakeholder is. The key stakeholders are marked in bold.

Table 2. Stakeholders for urban planning.

Stakeholders	
National government	Sustainable service providers
Subnational government	Civil society
Implementing and enforcement agencies/actors	Sustainable product/material providers
Building authorities and housing associations	Researchers
Architects and urban planners	Financial institutions
Property developers	Training and capacity institutions/providers
Utility companies and municipal service authorities	Business associations

4.1.3 Policy for urban planning

Urban planning policy can support goals for low-emission, efficient, and resilient buildings by enabling a local environment that has sustainable resources and where designers, developers, and owners have the support to invest in broader sustainable development goals. In the following sections, some possible measures are illustrated.

4.1.3.1 Integrated urban planning

Definition of activity

Integrated urban planning creates a formal framework to encompass multidisciplinary issues and the articulation of a clear city vision developed in collaboration with citizens. It is a process of communication and coordination among stakeholders at all stages of planning. Urban planning can contribute to sustainable development in many ways. It should be closely associated with the three intertwined dimensions of sustainable development: social development and inclusion, sustained economic growth, and environmental protection and management.

Describing sub-roadmap

1. Preparatory steps: Create commitment and political will as precondition for further activities. Start institutional coordination with ministries in charge of land use, transportation, buildings, energy, and environment. Introduce training and capacity building.
2. Strategy and conception: The development of a shared and integrated city vision requires alignment between different levels of government and across the motivations of different stakeholders involved in designing and implementing projects at the city level. Develop a concept on how to establish integrated urban planning in the overall national planning process.

3. Instruments: Develop an institutional structure for urban and territorial planning that coordinates urban, metropolitan, regional, and national plans and ensures consistency between the sectoral and spatial levels. The main legal instrument can be described as a formal framework to encompass multidisciplinary issues, such as climate change, disaster risk reduction, and emergency response, as well as land use and transport, location of services and infrastructure, social housing, and digital and open data information. Develop such a national framework and coordinate with all relevant sectors of the urban infrastructure and with relevant stakeholders.
4. Implementation and monitoring: Support and follow-up with development of visions for integrated planning on the city level. Initiate and support processes of communication and coordination among stakeholders at the local level. Regularly monitor the process in larger and midsize cities.
5. Evaluation and upscale: Evaluate country-wide process and development in terms of integrated planning. Use national vision and integrated planning framework as the basis to evaluate progress. Further scale-up approach and continue process with smaller cities and rural areas.

Describing the status quo of tier groups

- Early Development: Introducing training and capacity building on the development of urban plans.
- Moderate Development: Applying pilot approaches for urban planning and design, and including the topic of integrated urban planning in the trainings. No codes or policies are available for integrated urban planning.
- Advanced Development: Urban Planning Council and Master Planning Guidelines are established, the process of urban planning includes several disciplines such as transportation, social, and economic policies. The process goes through authority approvals and communication between different stakeholders such as water and electricity telecommunications companies, etc. Citizens are not included in the process of urban planning.
-

Next steps

- Early Development: Coordinate preparatory steps in terms of political will and stakeholder mapping. Work on an integrated urban development concept based on local background and needs. Bring together relevant stakeholders and parties to engage in further development of an integrated urban planning strategy to manage urban growth and land use planning.
- Moderate Development: Based on the learnings from pilot projects, scale-up the integrated planning approach and strategy for the whole country. Express political will to address integrated planning with an overall framework and establish mandatory integrated planning approaches and processes. Follow-up on trainings and capacity building of urban planners and other stakeholders like policy officers of relevant ministries, officers from municipal planning departments, private parties like investors, utilities, and housing associations. Include the citizenry in the development of an overall future city vision.

- **Advanced Development:** Enhance the planning process described in the Master Planning Guidelines and transfer requirements to the whole country. Translate voluntary recommendations into mandatory requirements.

4.1.3.2 Zoning regulation

Definition of activity

Local jurisdictions to integrate energy-related requirements into zoning regulations and streamlined “form-based” codes and land use plans. The objective is to create a specific type of energy-resilient, low-resource urban fabric. This initially could include special zoning districts that require increased sustainability and expand over time to include all zoning districts.

Describing sub-roadmap

1. **Preparatory steps:** Create commitment and political will as a precondition for further activities. Get all relevant actors involved dealing with urban planning aspects linked to the arrangement of urban structures to develop legal and institutional frameworks for zoning regulations and land use plans. Introduce relevant training and capacity building activities.
2. **Strategy and conception:** Start defining requirements that are crucial for the design of sustainable land use plans and corresponding zoning regulations. Include new development areas as well as upgrade and retrofit areas into the framework, which aims at adding low energy and environment protection-related aspects to the design of the urban form.
3. **Instruments:** Establish a country-wide system of processes and regulations that provide a solid long-term legal framework for land use planning. Develop a standard practice and relevant capacity in municipalities to issue and execute zoning regulations. The aim is to address all spaces of land use (land registration system) by optimising densities and urban structures, mobility and infrastructure development but also disclosing disaster-prone areas and protecting ecologically valuable areas. This is to be accompanied by capacity building activities.
4. **Monitoring and reporting:** Monitor status and performance of land use planning practice in local authorities. Set achievable spatial targets along appropriate timelines and assess territories covered by land use plans and applied zoning regulation. The monitoring should also include financial and personal capacities as well as availability of sustainable technologies and solutions.
5. **Evaluation and further steps:** Put in place a general evaluation system applicable to urban and territorial plans through legislative action. Develop sustainable performance indicators combining quantitative and qualitative information and analyses to evaluate outcomes and systems. Provide recommendations and adjustments to the local level based on the outcomes of a regular evaluation. Expand the system to the whole region or country.

Describing the status quo of tier groups

- **Early Development:** countries in this category are facing two key challenges: Firstly, a lack of national urban policy and its implementation strategy. Secondly, a strong desire for a practical land resolution mechanism and land registration system.

- **Moderate Development:** The regulations of the building code, set some instructions for planning on different scales. None of these regulations are concerning sustainability or building energy efficiency.
- **Advanced Development:** The Master Planning Guidelines covers the efficient use of resources and consideration of the environment and nature are integrated in generic zoning regulations. The duality of the usage of buildings, the efficient use of developable land and minimising space requirements and promoting transit-oriented development are all factors linking urban planning with sustainable buildings. Adopting practices that limit adverse impacts on the environment, the orientation of the urban grid, and buildings considering microclimate and thermal comfort are other factors representing the consideration of the environment and increase the sustainability.

Next steps

- **Early Development:** Based on the lack of urban and territorial planning policies and structures, capacity building and additional resources are key to develop an institutional setup and suitable regulations. Establish a land registration system as an information database and mapping system to register land use and ownership but also environmental resources, disaster risk likelihood, and access to public infrastructure. Start with preparatory steps for zoning and land use planning.
- **Moderate Development:** Based on existing regulations of the building code for spatial development, next step would be to develop and include sustainability criteria to these regulations. A sustainable planning concept and implementation strategy for new and existing areas should be generated to define indicators matching the local situation. A country-wide system of processes and regulations that provide a solid long-term legal framework can be established.
- **Advanced Development:** Establish a country-wide system of processes and regulations that provide a solid long-term legal framework for land use planning. Develop a standard practice and relevant capacity in all municipalities to issue and execute optimised zoning regulations.

4.1.3.3 Location efficiency and transit-oriented design

Definition of activity

Strategic integration of urban infrastructure and land use planning. Aim is to generate mixed-use communities that are location efficient, accessible through multiple modes of public transportation. Local jurisdictions should increasingly plan for interactions between buildings and connections with district energy resources that can enable zero-emission communities with clean energy and sustainable buildings.

Describing sub-roadmap

1. **Preparatory steps:** Bring together planning responsible, service providers and utilities on local level. Start process of cooperation and support the development of first ideas and drafts on how to plan and optimise energy efficient supply systems to buildings in certain areas.
2. **Strategy and conception:** Mapping of existing urban structures via GIS-based tools to develop a Climate and Energy Masterplan. Designate priority areas for certain

infrastructural or public space measures (e.g. district cooling, heat island mitigation measures like shading or air infiltration).

3. Instruments: Formulate and release Integrated Climate and Energy Masterplans for some pilot cities or urban areas. Follow an open and transparent process integrating the contributions of the private sector and civil society organisations. Collaborate with service providers, land developers, and landowners to closely link spatial and sectoral planning and to promote intersectoral coordination and synergies between services such as energy and electricity, transport, water, and sewerage. Support infrastructure development by offering funding opportunities or linkages to development banks. Support and supervise detailed implementation planning. This is to be accompanied by capacity building activities targeting the municipality and responsible staff.
4. Monitoring and reporting: Monitor implementation of targets and criteria described in the masterplan on the local level. Set achievable targets along adequate timelines and assess progress and outcomes of transit-oriented design approaches. The monitoring should include financial and personal capacities as well as the availability of sustainable technologies and solutions.
5. Evaluation: Develop sustainable performance indicators combining quantitative and qualitative information and analyses to evaluate outcomes. Provide recommendations and adjustments to the local level based on the outcomes of a regular evaluation. Expand climate- and energy-related master planning to all cities of the country.

Describing the status quo of tier groups

- Early Development: No location efficiency and transit-oriented design is available due to the lack of urban policies and legislations as a first step.
- Moderate Development: Only some examples of district cooling codes including district cooling criteria is available.
- Advanced Development: The Urban Planning includes variation of the densities of different districts according to the land use, as well as the distribution of retail densities. Limiting the industrial districts, transit accessible services would play a role in the interactions between different buildings.

Next steps

- Early Development: Provide background for efficient transit-oriented design approaches in terms of open data availability and setting up networks of stakeholders like planning departments and local service providers. Raise public awareness and strengthen capacities. Initiate investment planning, including contributions by the private sectors. Mobilise appropriate resources and locate essential urban services and infrastructure developments.
- Moderate Development: Based on experience from pilot projects, expand energy planning process to other urban areas. Introduce strategic planning in terms of master planning with timelines and targets for various urban areas. Increase network of stakeholders and service providers to support the process. Link to financial institutions and detect funding sources for further infrastructural developments.
- Advanced Development: Scale-up master planning to all urban agglomerations. Increase linkage of sectors and stakeholders to increase synergies and energy efficiency. Include

all relevant sectors like energy and electricity, transport, water, and sewage. Develop balances and scenarios on energy and water consumption as well as reduction measures over time combined with clear targets for 2030 and 2050.

4.1.3.4 Spatial planning and vertical integration

Definition of activity

Ensure collaboration among national, subnational, and city levels and across dimensions including transport, spatial planning, energy supply, and housing. Planners, developers, and designers can work together to increase the mixed-use nature of dense urban districts that have easy access to transit, retail, employment, entertainment, and residences to limit unnecessary energy use and emissions from transport and increase quality of life.

Describing sub-roadmap

1. Preparatory steps: Engage with principles of subsidiarity and multi-level governance and combine approach with the options of the specific governmental arrangements of each country. Introduce multiscale structure of territorial and urban planning.
2. Strategy and conception: Develop integrative and participatory decision-making processes. Incorporate competing interests and diverse visions to an overall development strategy and national, regional, and local urban policies.
3. Instruments: Provide national plans that steer economic development and large infrastructure to structure and balance the whole system. Prepare regional plans that strengthen urban-rural linkages and adapt to climate change impacts. Focus on urban scale and develop city strategies and integrated development plans that prioritise investment decisions and encourage synergies between sectors and urban areas. Issue land use plans that serve the protection of environmentally sensitive areas and the regulation of sustainable construction. Finally, support the neighbourhood level via local development and public space plans to improve urban quality, social cohesion, and the protection of local resources. This is to be accompanied by capacity building activities.
4. Monitoring and reporting: Monitor status of vertical approach and planning practice. Set achievable targets along adequate timelines and assess performance and transparency of multi-level processes.
5. Evaluation and further steps: Put in place a general evaluation system that assesses the consideration and implementation of sustainability targets and criteria with the planning practice. Provide recommendations and adjustments based on the outcomes of a regular evaluation.

Describing the status quo of tier groups

- Early Development: No spatial planning activities related to energy efficiency are available due to the lack of urban policies and legislations.
- Moderate Development: No space planning regulations are available. None is covered by laws, codes, or regulations.
- Advanced Development: The hierarchy of planning open spaces is mentioned in the city's plan, to create an integration between formal and informal areas. The land use

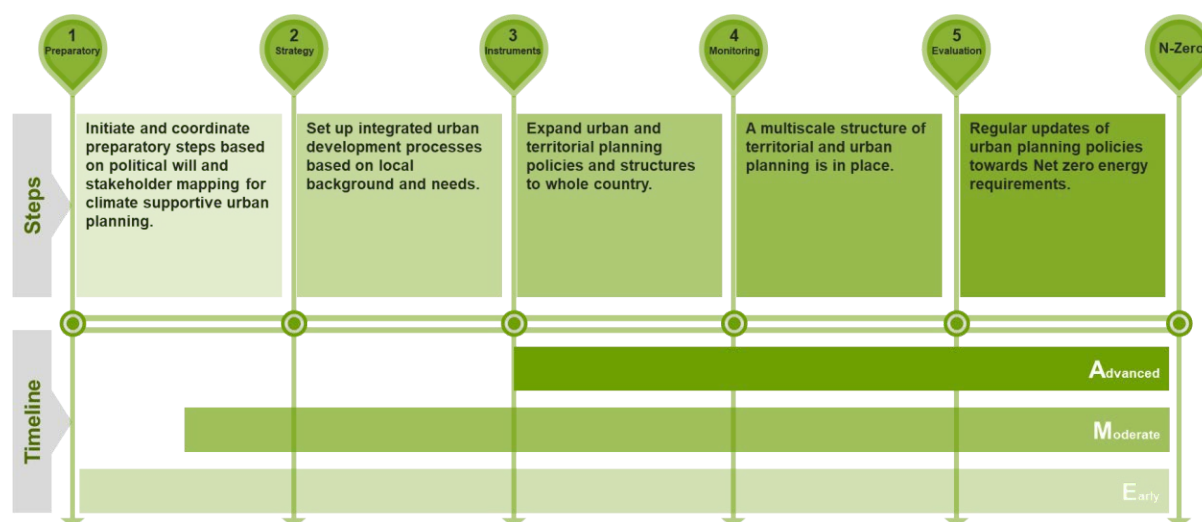
compatibility is covered under the Master Planning Guidelines considering any clashes that could occur between different uses.

Next steps

- Early: Prepare principles of subsidiarity and multi-level governance and combine approach with the options of the specific governmental system. Introduce multiscale structure of territorial and urban planning.
- Moderate: Introduce sustainable space planning guidelines and regulations at the municipal levels. Those guidelines and regulations should be driven from the national sustainable vision in place. Increase multi-level governance approaches and cooperation between institutions on the local, regional, and national levels.
- Advanced: Scale-up city guidelines and plans to national and regional levels. Create overall spatial planning policies and regulation for the whole country. Support vertical approach and planning practice. Set achievable targets along adequate timelines and assess performance and transparency of multi-level processes.

4.1.3.5 Sub-conclusion

Figure 17 shows the main (aggregated) steps to decarbonise the policy for Activity 1. The bottom half of the figure illustrates the mapping of the three development phases and the upper half shows the recommended steps.



Key message: Because urban planning has a low investment value but high impact on the pathway to climate neutrality, integrated approaches connecting sectors and looking for synergies should be common practice.

Figure 17. Roadmap for Activity 1 – urban planning, policy.

4.1.4 Technology for urban planning

Technology can enable increased action toward low-emission, efficient, and resilient buildings when coupled with urban planning. Specific sub-activities, targets, and timelines for sustainable urban planning technologies are outlined in the following sections.

4.1.4.1 Digital tools

Definition of activity

Support the increased use of tools that use data and information (such as satellite images), cost data, benefits analysis, and lifecycle analysis to make science-based decision-making in the urban planning process.

Describing sub-roadmap

1. **Initiate:** Assess data availability and instruments to support the urban digitalisation process. Increase capacity building of all relevant stakeholders in terms of digital knowhow and possible applications. Invest in sensors and other data gathering infrastructure including public participation into data collection. Take precautions for privacy, data protection, and security issues.
2. **Knowledge:** Install open data platforms and make as much information as possible about city operations available to the public via city data dashboards or information screens in public spaces. Measure quality of air, water, and solid waste and assess processes and efficiency of infrastructure, energy, traffic, and public transport. Make sure shared data is available to all relevant actors and institutions of the planning process.
3. **Practice/upscale:** Collected data and tools are in place in most cities (like Geographical Information Systems, GIS) to improve the urban planning process. Built up intelligent infrastructure in pilot areas like smart grids (power grids in which power generators, grid operators, power consumers, and power-storing are networked) linked with smart homes (digital technologies for automation and demand-side control) as well as intelligent systems to optimise traffic flow and logistics. Upscale intelligent planning and smart infrastructure to all cities.
4. **Mainstream:** Monitor data collection process and improve quality of collected information. Combine datasets of diverse sectors to increase integrated planning and reveal synergies. Regularly update data and publicly available information. Evaluate the use of digital urban planning tools in municipalities. Provide support and capacities to the local level.

Describing the status quo of tier groups

- **Early Development:** No digital tools are available as a technology used for urban planning in the fields of cost data, benefit analysis, or lifecycle analysis.
- **Moderate Development:** The initiative for using digital tools in planning is still limited to the field of research—there is no current application on the ground. The GIS application is only used by the General Organisation for Physical Planning; it is not used for cost data, benefit analysis, or lifecycle analysis.
- **Advanced Development:** Implementing Smart City Index, where one of the classifications of the cities depend on the mobility supported by different mobile applications showing the integration of the digital tools in the urban planning and the presence of the supporting technology (IMD et al. 2021). Solar Atlas website is another channel of the integration of digital tools.

Next steps

- Early: Assess data availability and instruments to support the urban digitalisation process. Invest in sensors and other data gathering infrastructure. Install open data platforms and make information about city operations available. Make sure shared data is available to all relevant actors and institutions of the planning process.
- Moderate: Install open data platforms and make information about city operations available. Collected data and tools are in place (like Geographical Information Systems, GIS). Built up intelligent infrastructure in pilot areas.
- Advanced: Collected data and tools are in place (like Geographical Information Systems, GIS). Upscale intelligent planning and smart infrastructure to all cities.

4.1.4.2 District energy

Definition of activity

Where district energy (heating and cooling) has a low lifecycle cost compared to other energy solutions, support the increased use of district energy technologies that can transition district energy networks to be efficient and use renewable energy sources, such as co-generation, industrial waste heat, biomass, geothermal, and wind or solar energy.

Describing sub-roadmap

1. Initiate: Assess existing district energy infrastructure via GIS-based maps and locate potential for extension or new areas for district energy networks. Include district cooling and heating demand-side assessment with densities of the urban structure, energy generation options as well as waste heat potential or natural resources (sea water).
2. Knowledge: Include the public and all relevant stakeholders in the planning process. Provide financing models and funding opportunities for district infrastructure. Support new business models for energy communities and develop codes for district energy supply. Extend mapping and potential studies to all relevant urban areas.
3. Practice/upstream: Increased expansion or new installation of district energy systems in all dense urban areas. Generation of public or private energy communities to supply renewable energy into district networks. Increase share of renewable energy to these networks. All district energy networks have a share of at least 50% renewable energy. Regulate energy prices and market development.
4. Mainstream: Assess share of households connected to district energy. Support connection rate and re-densification of the network. All district energy systems are sustainable, efficient, and 100% served by renewable energy.

Describing the status quo of tier groups

- Early Development: No district energy is applied as a technology for urban planning.
- Moderate Development: A code for district cooling is in place.
- Advanced Development: There is a mature implementation of the district energy system, where the regulation intends to optimise energy infrastructure and enhance the adoption of more efficient cooling systems. No integration of renewable energy.

Next steps

- Early: Assess existing district energy infrastructure via GIS-based maps. Locate potential for extension or new areas for district energy networks.
- Moderate: Provide financing models and funding opportunities for district infrastructure. Support new business models for energy communities and develop codes for district energy supply. Extend mapping and potential studies to all relevant urban areas.
- Advanced: Increased expansion or new installation of district energy systems in all dense urban areas. Increase share of renewable energy to these networks. Regulate energy prices and market development.

4.1.4.3 Exterior lighting

Definition of activity

Support the increased use of smart and efficient lighting in the exterior of buildings and streets. Smart lighting includes sensors and controls and can be integrated with other environmental and site conditions information such as traffic.

Describing sub-roadmap

1. Initiate: Assess current state of public exterior lighting. Develop regulatory instruments and information labels to build a basis for larger rollout of efficient street lighting.
2. Knowledge: Enhance capacity building and financing mechanisms to transfer to efficient lighting systems in all public areas. Develop maps and systems to assess quality of lighting of streets and places.
3. Practice/upstream: Transfer to photocontrol, astronomical time clock, and energy management control systems in all public spaces.

Describing the status quo of tier groups

- Early Development: No smart or efficient lighting is used for building exteriors or streets.
- Moderate Development: Promoting projects of improving energy efficiency of lighting and building appliances, through a combination of regulatory tools such as minimum energy performance standards and enhancing public awareness, capacity building, and attractive financing mechanisms.
- Advanced Development: Development of a Lighting Regulation aiming for a reduced ecological footprint, highlighting the sustainability impact assessment, and sharing a policy and regulatory framework.

Next steps

- Early: Assess current state of public exterior lighting. Develop regulatory instruments and information labels to build a basis for a larger rollout of efficient street lighting.
- Moderate: Enhance capacity building and financing mechanisms to transfer to efficient lighting systems in all public areas. Develop maps and systems to assess lighting quality of streets and places.
- Advanced: Transfer to photocontrol, astronomical time clock, and energy management control systems in all public spaces.

4.1.4.4 Water management

Definition of activity

Support the increased use of water management technologies that reduce water run-off and increase landscape permeability and rainwater retention. This can support resilience against floods and improved health of soil and underground aquifers.

Describing sub-roadmap

1. **Initiate:** Prepare interactive maps based on satellite data on rainfall, land surface temperature, soil moisture, and vegetation. Gather information on water quality and end use to generate a minimum water requirement programme.
2. **Knowledge:** Promote technologies to treat and reuse wastewater for productive purposes. Organise financing for municipalities to recycle wastewater and establish water management systems. Improve cooperation between land and water management. Carry out assessments on water demand, wastewater onset, and water supply. Provide capacity on the local level to proactively manage droughts and water scarcity. This is to be accompanied by capacity building activities.
3. **Practice/upstream:** Roll out solar-powered pumping programmes for irrigation purposes. Use remote sensing techniques to control the expansion of groundwater-based irrigation. Install water management departments in all local authorities. Establish grey water and water recycling systems in all new development areas.
4. **Mainstream:** Innovative monitoring technologies are in place (like remotely controlled pumps and smart water meters) to steer water usage and wastewater emergence. Pricing policy is used as a demand management tool.

Describing the status quo of tier groups

- **Early Development:** The status is in a stage earlier than water management serving resilience. Substantial percentage of the produced fresh water does not reach consumers due to old or fractured pipes in the water distribution networks. Further, some segments of the network contain asbestos pipes and other hazardous materials, and water pumps are consistently malfunctioning because of a considerable cost of reparation and lack of maintenance funding.
- **Moderate Development:** Only few initiatives are available addressing the integrated urban water management such as projects aim to improve the sewage system to cope with the rainfall in winter.
- **Advanced Development:** Country guideline promoting the use of alternative water resources; by recovering air conditioning (AC) condensate from all units above and reuse onsite for irrigation or toilet flushing and undertaking a feasibility study to assess installation of an onsite greywater recycling system and promotes the availability of the water recycling technologies on a building scale.

Next steps

- **Early:** Prepare interactive maps based on satellite data on rainfall, land surface temperature, soil moisture, and vegetation. Gather information on water quality and end use to generate a minimum water requirement programme.

- Moderate: Prepare interactive maps based on satellite data on rainfall, land surface temperature, soil moisture, and vegetation. Improve cooperation between land and water management. Carry out assessments on water demand, wastewater onset, and water supply.
- Advanced: Water management departments are installed in all local authorities. Grey water and water recycling systems are established in all new development areas. Innovative monitoring technologies are in place.

4.1.4.5 Urban ecology

Definition of activity

Increase vegetation in, on, and around the building to improve shading, air quality, management of stormwater, the urban heat island effect, and human physiology. Include nature-based solutions in urban planning. Take action to restore and protect natural ecosystems and establish new ecosystems to foster biodiversity and social benefits.

Describing sub-roadmap

1. Initiate: Raise awareness on significance of urban green and blue spaces. Build capacity and a financial basis for increased inclusion of ecological aspects in urban planning and the built environment.
2. Knowledge: Set up masterplan and guidelines with focus on urban ecology. Prepare a regulatory framework to set requirements for urban ecology. Increase planning knowhow and capacity to support green city approaches.
3. Practice/upstream: Expand Forest areas to capture gaseous pollutants in urban areas, plant windbreaks for soil conservation, install green roofs for biodiversity enhancement, and increase green areas as carbon storage and rainwater retention. Regulations to include enhanced ecology requirements in the urban space are in place and executed by local authorities in all new development and restoration areas.
4. Mainstream: Set up communication projects to include citizen in the local communities. Initiate parenthood initiatives for green spaces and public parks. Define responsibilities and select a caretaker for maintenance of green spaces.

Describing the status quo of tier groups

- Early Development: Urban ecology and climate adaptation activities are not available in due to the lack of urban policies and legislations as a first step.
- Moderate Development: Only few initiatives are available: the green roof, waste recycling, food and energy rationalisation, air pollution reduction, and plastic use abatement initiatives.
- Advanced Development: Buildings guideline requesting for an assessment of the ecology of the site to protect any valuable natural assets, also the requirements to limit the effect of urban heat island with the requirements of utilizing a minimum of at least 50% of the site's hardscape with initial solar reflective index (SRI) ≥ 29 . Additionally, a minimum of at least 75% of the building's roof surface, excluding skylights, building equipment (mechanical equipment, solar hot water panels, PV equipment), and green roofs, must comply with an SRI requirement of ≥ 78 for low sloped surfaces and ≥ 29 for steep sloped surfaces. In other cases, it is instructed that new buildings should have a vegetation coverage of 30% of the roof area. No other regulations are set for the air quality or the

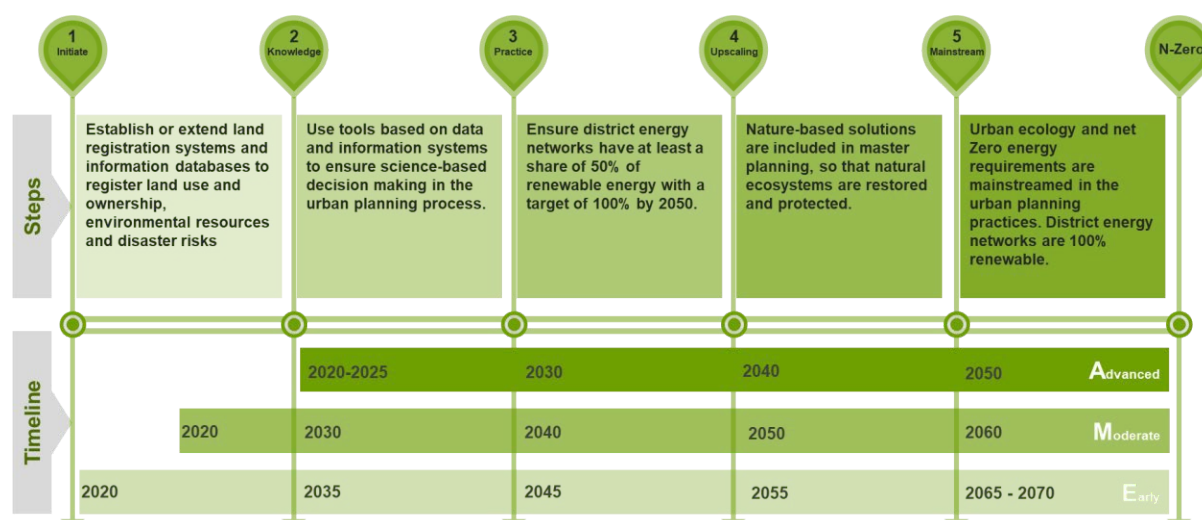
urban heat island effect creating reference values. The regulations included requirements to assure the protection and enrichment of native habitats, reduce water consumption, and use native vegetation stockings to enhance energy conservation. The master planning guidelines provides consideration of solar orientation, shading, wind, and noise.

Next steps

- Early: Raise awareness on the significance of urban green and blue spaces. Built capacity and a financial basis for increased inclusion of ecological aspects in urban planning and the built environment.
- Moderate: Set up masterplan and guidelines with a focus on urban ecology. Prepare a regulatory framework to set requirements for urban ecology.
- Advanced: Expand Forest areas, install green roofs, and increase green areas as carbon storage and rainwater retention. Set up communication projects to include citizen in local communities. Define responsibilities and caretaker for maintenance of green spaces. Additionally, monitor and assess urbanization and its negative impact on green areas and Mangroves.

4.1.4.6 Sub-conclusion

Figure 18 shows the main (aggregated) steps to decarbonise the technology for Activity 1. The bottom half of the figure illustrates the mapping of the three different development phases and the upper half shows the recommended steps.

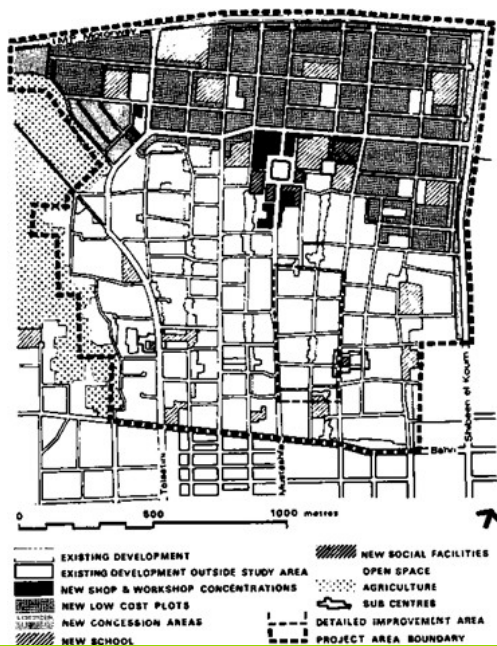


Key message: Technologies and approaches to support the urban planning process should be available to all stakeholders involved in the process.

Figure 18. Roadmap for Activity 1 – urban planning, technology.

4.1.5 Best practices

Policy/Planning: Land and Services Policy, City of Ismā'īliya Development



In 1978, the informal al-Salām district of Egypt was developed using a Land and Services approach to improve the living conditions of its residents and transform the district into a formal area. This urban development project was based on two principles. First, the project recognised people as the real owners of the development process. Second, the land was considered as a resource to meet the needs of the people instead of treating land as a financial source to increase state resources. The model acknowledged the partnership between residents and local authorities and treated the residents as actors involved in the development process (and not beneficiaries). The success of this project was attributed to the establishment of a competent committee to manage the project.

Source: Davidson, Forbes. 1981. "Ismailia: From master plan to implementation." *Third World Planning Review* 3(2), p. 161–178.

Technology/Implementation: The Sustainable City, Dubai Development

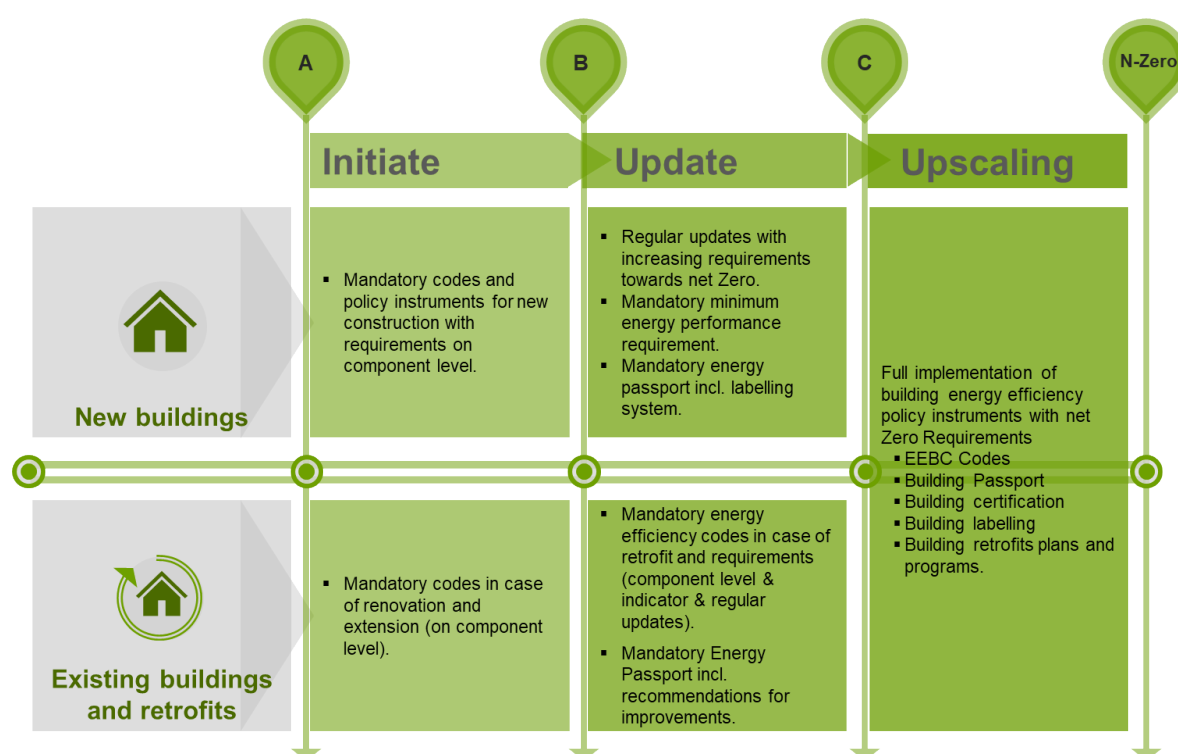


Source: <https://www.thesustainablecity.ae/home/>

The Sustainable City is a 46-hectare property in Dubai and is the first net-zero energy consumption masterplan in Dubai. It brings together several sustainability concepts to design a mixed-use community space. The Sustainable City includes 11 natural biodome greenhouses for urban farming, aiming to diversify food production. Other elements of the Sustainable City include two parking spaces shaded by solar panels plus additional spaces for communal electric buggies for each villa, wastewater recycling, and a 10 m high buffer zone for purifying air entering the city.

4.2 Activities 2 and 3: New buildings and buildings retrofit

In principle, the evolution of policy instruments governing the energy efficiency in the buildings sector starts with mandatory building codes for new construction with energy efficiency requirements on the building component level and at the building level. The next step is to update and extend those codes (and other policy instruments) to cover the renovation and extension projects. The next step to update and extend those codes (and other policy instruments) is to cover the renovation and extensions projects. For further development, those policy instruments are being updated to cover the entire building sectors. The following figures explain those three phases. The policy instruments should include, among others, codes, building passports, building labelling and retrofit plans. The regular update of the policy instruments should aim at increasing the energy efficiency requirements towards net Zero requirements.



Evolution of policy instruments governing energy efficiency in the buildings sector. Start focusing on new buildings then to update the instruments to gradually cover extension, retrofit, and existing buildings.

Figure 19. Evolution of Policy instruments governing EE.

4.2.1 Key actions for sustainable new buildings

Based on the screening and data collection about the status of policy instruments governing the building sector in the countries of focus of this report, the countries have been categorized in three groups of early, moderate, and advanced. The following points explain the key actions to be taken in each category for more sustainable new buildings. The following points explain the key actions to be taken in each category (development phase) for more sustainable new buildings.

Key actions to enable increased energy efficiency for buildings in early starter countries:

- Establish a governmental committee or entity to lead and develop the energy efficiency policy instruments in the buildings sector. Alternatively, assign this responsibility to an existing governmental entity or a unit.
- Develop and implement mandatory EEBCs energy efficiency building codes. Elaboration of the code including the clear compliance procedures of all construction phases (design, construction, and occupancy permits).
- Increase awareness and information about the benefits of more sustainable buildings to enable consumers to make better choices and which can enable more advantageous financing.

Key actions to enable increased energy efficiency for buildings in moderate countries:

- Update EEBCs energy efficiency building codes. To strengthen the energy performance requirements with aspirations of achieving net-Zero. The update should include a clear procedure for compliance.
- Ensure that adequate capacity building programmes and tools are in place to enable code compliance across the buildings sector.
- Update the voluntary certification scheme with defined clear roles including the certification body, the auditors' roles, and associated training programmes. The scheme should be accompanied with fiscal or non-fiscal incentives.

Key actions to enable increased energy efficiency for buildings in advanced countries:

- Establish an effective system to regularly update the EEBCs. The code update must aim at zero energy buildings.
- Update the local building rating schemes. The schemes must consider lifecycle assessment (LCA) and reducing embodied emissions.
- Implement a mandatory building passport for new buildings. The scheme to consider restricts requirements towards net-Zero buildings. The building passport must be part of all rental and purchasing of new buildings.

4.2.2 Key actions for sustainable building retrofits

In many countries the existing building stock represents the large majority of the overall building stock and buildings-related emissions to 2050. The performance of existing buildings must be improved to be near zero emissions through an increase in the renovation rate and an upgraded level of energy efficiency performance. Today's renovation rates generally amount to a minimal percentage of the existing stock each year, typically without energy efficiency improvements. These improvement rates are not in line with energy and emissions targets to limit average temperature rise to 2°C or less, and renovation investments are often not at the optimal cost-effective technical potential that can achieve higher performance. The following points explain the key actions to be taken in each category for more sustainable buildings existing buildings and building retrofit projects. The following points explain the key actions to take in each category (development phase) for more sustainable existing building and building retrofit projects.

Key actions to enable increased energy efficiency for buildings in early starter countries:

- Set up a wide national renovation plan. Include economic analysis considering the cost optimality principles, secure financing options, and set up energy auditing and performance verification procedures for building retrofit projects.
- Develop and implement EEBCs for existing buildings. The implementation may be on a voluntary basis with the vision to make it mandatory for all retrofit and refurbishment projects.
- Increase awareness and information about the benefits of more sustainable buildings to enable consumers to make better choices and which can enable more advantageous financing.

Key actions to enable increased energy efficiency for buildings in moderate countries:

- Update BEECs. To cover existing buildings, include all types and sizes to strengthen the performance requirements every 3-5 years with aspirations of achieving zero.
- Establish a mechanism for energy audits of buildings (e.g. code, standard, instructions). Existing buildings must be subject to regular energy auditing on a regular basis.
- Ensure that adequate capacity building programmes and tools are in place to enable compliance with energy auditing for existing buildings and mechanisms are in place across the buildings sector.

Key actions to enable increased energy efficiency for buildings in advanced countries:

- Disseminate the building renovations and retrofit plans and programmes widely. Expand the implementation of existing retrofit programmes to cover other cities and geographic regions in the country.
- Increase the depth of renovation. Enable deep energy renovations that reduce the energy consumption of existing building by 30%-50% or more.
- Implement a mandatory building passport for new and existing buildings. The scheme to consider restricts requirements towards net-Zero buildings. The building passport must be part of all rentals and purchasing of new buildings.

4.2.3 Stakeholders for sustainable new buildings and building retrofits

In the Arab Region, the key stakeholders for sustainable new buildings include those that can influence new buildings and those that can deliver the results of low-emission, efficient, and resilient buildings. Additional stakeholders include those that can support the process through research, funding, training, and making technologies available. All these stakeholders are essential to delivering on roadmap targets. Table 3 shows the stakeholders; the darker the colour of the cell, the more relevant the stakeholder is. The key stakeholders are marked in bold.

Table 3. Stakeholders for sustainable new buildings and building retrofits.

Stakeholders	
National government	Sustainable service providers
Subnational government	Civil society
Implementing and enforcement agencies/actors	Sustainable product/material providers
Building authorities and housing associations	Researchers
Architects and engineers	Financial institutions
Property developers	Training and capacity institutions/providers
Utility companies and municipal service authorities	Business associations

4.2.4 Policy for sustainable new buildings and building retrofits

New and retrofit buildings policy can be developed to enable each building to be low-emission, efficient, and resilient. Many policies are highly effective as there are clear approval and permit processes that enable improved enforcement.

4.2.4.1 Building energy efficiency codes and compliance (new buildings)

Definition of activity

Building energy codes or standards provide minimum requirements for building components or for building performance that can enable zero-emission, efficient, and resilient new buildings and upgrades to existing buildings during major renovations and refurbishments. Building codes should be mandatory and cover all types of buildings and be based on a whole lifecycle carbon approach (including operational carbon and embodied carbon). These aim towards net-zero emission buildings at the lowest cost by ensuring the highest efficiency levels first. Building codes should include, or refer to, locally adapted bioclimatic design principles to optimise passive design. First building codes should be prescriptive in format, evolving into performance-based codes. Specific standards and guidelines and tools for social housing and the informal sector can be used to facilitate compliance in this sector.

Describing sub-roadmap

1. Preparatory steps: If it is not in place, first establish a governmental committee or entity to lead and oversee policy of energy efficiency in the buildings sector. Initiate the process to elaborate the EEBC, to be led by the responsible governmental entity. This should include the definition of involved stakeholders and formation of working groups or committees such as the technical expert groups to elaborate the code. This should also include a study of the different climatic zones in the country.
2. Strategy and conception: Develop the code including the definition of the suitable type of the code e.g. prescriptive, trade-off, performance-based, or a mixed approach. Targets and levels of stringency to be defined with clear indicators and market suitable methods/techniques. Building types to be covered in the code must also be identified. The code must consider the different climatic zones in the country. The code should consider the principles of cost optimality of the building performance requirements. For more information about cost optimality, check this [link](#).
3. Instruments: Prepare an implementation and enforcement plan that includes the compliance procedures that must be considered during the following building construction stages: a) before issuing the construction permit (design phase), b) at the construction phase, c) before issuing the occupancy permit, and d) occupancy permit.

The implementation plan should include clear roles at the municipal level and capacity building programmes for the municipal staff. A gradual implementation approach can be also considered. The gradual implementation may start with focusing on certain building types (e.g. public buildings then high consumers such as commercial buildings, malls, and hotels, then large residential buildings, and finally residential). The implementation plan may also be initiated focusing on a certain geographic area (e.g. a district or a city). Other enforcement options should be considered (e.g. third-party verification). This step should be accompanied by capacity building activities targeting municipal responsible staff, architects, and building project developers.

4. **Monitoring and reporting:** Monitor the implementation of the code and conduct an assessment to define the gaps and barriers in terms of technical requirements, procedures, and administrative aspects. The monitoring phase should conclude with recommendations to expand the implementation to cover other building types, cities, and geographic regions. In this step, all new buildings must comply with the code.
5. **Step 5: Evaluation:** Establish an effective system for a regular update of the code. The regular update cycle must consider the lessons learned from the monitoring and evaluation. Additionally, it is necessary to involve relevant stakeholders. The update of the code must aim at zero-energy buildings requirements.

Describing the status quo of tier groups

- **Early Development:** EEBCs are not in place.
- **Moderate Development:** The Energy Efficiency Buildings Code covers new buildings and new extensions of the building. Both codes provide two approaches: a prescriptive approach and a performance-based approach. The codes cover many aspects such as building envelope, natural ventilation and thermal comfort, water heating, lighting, electrical power, and whole building performance. Codes have not been enforced for application and implementation. The compliance with social housing or informal sector is still not available.
- **Advanced Development:** The buildings guidelines require comprehensive provisions and measures covering energy performance, energy metering, building envelope, renewable energy utilization and energy efficient appliances. The guidelines seek to reduce the building's energy consumption by using appropriate materials, energy efficient fixtures and systems as well as design choices. The codes are well enforced and implemented.

Next steps

- **Early Development:** Steps 1-3 until 2030: Coordinate preparatory steps including the evaluation of current building regulations and formulate working committees to develop the EEBC. Prepare and implement an enforcement plan covering the building construction phases and with clear municipal procedure and capacity building programmes for the Municipality.
- **Moderate Development:** Steps 3-4 until 2030: Update the existing code. Prepare an enforcement plan with clear compliance procedures covering all construction phases. Monitor and evaluate the implementation to define the gaps and barriers in terms of technical requirements, procedures, and administrative aspects. All new buildings must comply with the code.

- Advanced Development: Step 5 until 2030: Establish an effective system to regularly update the code. The update of the code must aim at zero energy building requirements.

4.2.4.2 Codes for existing buildings and compliance

Definition of activity

These refer to standards requiring improvements to the building's envelope or systems in the event of significant works, whether they were part of an energy retrofit or not. Codes should be developed with respect to segments (e.g. commercial, multifamily residential, single-family homes) and should ensure that refurbishments are carried out to align the performance of existing buildings to their cost-effective potential.

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

Describing sub-roadmap

1. Preparatory steps: Initiate the research phase to be led by the responsible governmental entity. This should include definition of involved stakeholders, formation of working groups and/or committees such as the technical expert groups to elaborate the energy efficiency building code for existing buildings.
2. Strategy / conception: Elaboration of the energy efficiency building code for buildings retrofit projects and for existing buildings. This might be a part of the update of a general energy efficiency building code. This step should be accompanied by capacity building activities targeting municipal responsible staff, architects and building projects developers.
3. Instruments: Implementation and enforcement plan to be prepared that should include the elaboration of the compliance procedures that must be considered in retrofit and refurbishment of buildings. The procedures should cover the stages of a) before retrofit (design phase, with energy efficiency measures), b) at the construction of the proposed retrofits phase, and c) occupancy permit (when necessary). The implementation plan should include clear roles at the municipal level and capacity building programs for the municipal staff. A gradual implementation approach can be also considered. The gradual implementation may start with focusing on certain building types e.g., public buildings, then high consumers such as commercial buildings, malls, hotels, and then large residential buildings and finally residential. The implementation plan may also be initiated focusing on a certain geographic area e.g., a district or a city.
4. Monitoring and reporting: Monitor the implementation of the code and conduct an assessment to define the gaps and barriers in terms of technical requirements, procedures, and administrative aspects. The monitoring phase should conclude recommendations to expand the implementation to cover other building types, cities, and geographic regions. Ideally, in this step, all building retrofit projects must comply with

code. Monitoring and reporting of the building energy performance must be collected in a database covering the building stock. Such a database will enable the municipalities and cities to monitor the energy performance, define key gaps, and set recommendations to improve energy efficiency at the city level. This is to be executed in cooperation with other relevant stakeholders such as electricity and energy providers.

5. Evaluation: Establish an effective system for a regular update of the code. The regular update cycle must consider the lessons learned from the monitoring and evaluation. The update of the code must aim at zero-energy buildings requirements.

Describing the status quo of tier groups

- Early Development: A code for retrofitting of buildings is not available.
- Moderate Development: Energy efficiency building codes cover the building as new or existing, materials, building envelope, natural ventilation and thermal comfort, water heating, lighting, electrical power, and whole building performance. There is no codes for retrofitting.
- Advanced Development: Guidelines covering the operations and maintenance (O&M) and all aspects of running an asset over the course of its useful life. This includes the reduction and optimisation of energy usage, reduction and optimisation of water usage, reduction of harmful emissions, and protecting the environment and natural resources. Building retrofits program are established for specific building's types.

Next steps

- Early Development: Steps 1-3 until 2030: Coordinate preparatory steps including the evaluation of current building regulations and formulation of working committees to elaborate the EEBC for existing buildings and building retrofit projects. Prepare and implement an enforcement plan with clear municipal procedure and capacity building programmes for the Municipality.
- Moderate Development: Step 1-4 until 2030: prepare energy efficiency building code for existing buildings. To prepare an enforcement plan with clear compliance procedures. Monitor and evaluate the implementation to define the gaps and barriers in terms of technical requirements, procedures, and administrative aspects. To update the EEBC and its implementation and enforcement plan. All building retrofit projects must comply with the code.
- Advanced Development: Step 5 until 2030: Establish an effective system for a regular update of the code to cover all building retrofit projects. Expand the existing retrofits and programs to cover more building types and geographic areas.

4.2.4.3 Informal buildings sector

Definition of activity

Capacity building, accessible construction guidelines and tools, and wide stakeholder engagement will be key to increasing the compliance with codes in the informal buildings sector.

Describing sub-roadmap

1. Preparatory steps: Initiate the research phase with the definition of the construction baseline (building typologies) and their energy efficiency levels in the informal areas. Define targets, goals, and possible interventions.
2. Strategy / conception: Define guidelines and/or packages of interventions to improve the EE in the buildings in informal sector. Prepare a simplified version of the EEBC to be suitable for the informal sector. Prepare guidelines and procedures for compliance with the code. This should be prepared in cooperation with stakeholder involved in the building's construction in informal areas and with capacity building programs.
3. Instruments: Prepare tools for a simplified compliance with the codes. That may include simplified versions of the codes and a checklist suitable for the informal sector. Training for municipal staff to implement the simplified versions of the codes. Implementation in a gradual approach in a specific pilot area or specific energy efficiency measures. Prepare a stakeholder's outreach plan to promote energy efficiency in the informal sector.
4. Monitoring and reporting: Monitor the implementation of the pilot phase of the simplified compliance in informal areas. This should conclude the gaps and barriers in terms of technical requirements, procedures, and administrative aspects as well. The monitoring phase should conclude recommendations to expand the implementation to cover other building types, cities, and geographic regions.
5. Evaluation: Establish an effective system for a regular update of the simplified code. The regular update should aim for stronger energy efficiency measures.

Describing the status quo of tier groups

- Early Development: Only a limited number of urban development plans exist to upgrade the informal areas.
- Moderate Development: Established entities to develop and upgrade the informal settlements. The inclusion of the informal sector is still not in focus; the first step is enforcing the mandated energy efficiency code.
- Advanced Development: It is not relevant to few countries as there are no informal buildings/areas in some countries. Other advanced countries with informal settlements have several national and international entities that prepared studies and implemented projects to improve and upgrade informal areas providing an appropriate understanding about the general situation, but energy efficiency was not in priority in most of them as the focus was on providing essential services and infrastructure upgrade.

Next steps

- Early Development, Steps 1-2 until 2030: Establish a committee to study and research the energy efficiency levels of buildings in the informal areas. Prepare guidelines for interventions to improve the energy efficiency in the informal sector at the building component levels.
- Moderate Development, Steps 1-3 until 2030: Establish a committee to study and research the energy efficiency levels of buildings in the informal areas. Prepare guidelines for interventions to improve the energy efficiency in the informal sector at the building component levels. Prepare tools for a simplified compliance with the codes. That may include simplified versions of the codes and a checklist suitable for the informal sector.

This must be accompanied by capacity building programmes for involved stakeholders and municipal staff.

- Advanced Development, Steps 1-3 until 2030: Establish a committee to study and research the energy efficiency levels of buildings in the informal areas. Prepare guidelines for interventions to improve the energy efficiency in the informal sector at the building component levels. This should be prepared in cooperation with stakeholders involved in the building's construction in informal areas. Prepare tools for a simplified compliance with the codes. That may include simplified versions of the codes and a checklist suitable for the informal sector.

4.2.4.4 Building labelling (Energy Performance Certificate)

Definition of activity

Quantitative building energy performance labelling can be used to assess “as designed” building performance on a scale of less to more efficient. Labelling enables increased information sharing and awareness for consumers and investors. Labelling can also be linked to incentives and financial tools. Certification such as green building certification overlaps with this policy as another form of assessing performance. Labelling and certification systems should be continuously monitored and revised to ensure the top rating is truly reserved to the top performing buildings of the market - or clearly linked to a long-term objective to avoid frequent updates of rating scales.

Describing sub-roadmap

1. Preparatory steps: Research and define of the appropriate approach to rate and classify the buildings (e.g. thermal dynamic simulation tools, simplified calculation methods, points-based methods). Develop a locally adopted calculation methodology, which can be based on one of the internationally recognised methodologies. Climatic data must be common inputs and boundary conditions for the energy calculations.
2. Strategy and conception: Prepare the format of building labels including the definition with clear requirements and KPIs defining the energy efficiency classes. Calculation could consider the overall performance of the building, the building elements level (such as roofs, facades, and windows), and components of technical building systems (such as thermal solar collectors, PV panels).
3. Instruments: Prepare an implementation plan including gradual implementation starting with certain building types (e.g. public buildings, then high consumers such as commercial buildings, malls, and hotels, then large residential buildings, and finally residential). The implementation plan may also be initiated focusing on a certain geographic area (e.g. a district or a city). The plan defines clear municipal procedures for issuing the label. In this phase, the labelling scheme is mandatory for new buildings and voluntary basis for existing buildings. This step should be accompanied by capacity building activities targeting municipal responsible staff, architects, and building project developers.
4. Monitoring and reporting: Monitor the implementation of the pilot phase of the labelling scheme. The monitoring must also include an auditing process, which might be executed by certified auditors from the municipality or from a third party (e.g. energy audit companies and certified consultants). In this step, the labelling scheme should

be updated to be a mandatory scheme for all building extensions and building retrofit projects.

5. Evaluation: Define the gaps and key recommendations to expand the scope of the compliance with the rating scheme and implement it in other areas or include other measures. Establish an effective system for regular update the certification scheme. Update the building label with more restrict requirements towards net-zero buildings. Full enforcement of the labelling scheme should be achieved in this step with high penetration of 30%-40% in the building stock.

Describing the status quo of tier groups

- Early Development: No building labels are implemented.
- Moderate Development: No labelling scheme is implemented. An energy classification scheme is under development.
- Advanced Development: Developing a simplified online tool with the option of verified and unverified ratings for residential and commercial buildings, intending to rate actual operational performance of existing residential and commercial buildings on a voluntary basis.

Next steps

- Early: Steps 1-2 until 2030: Research and define the appropriate approach to rate and classify the buildings based on their energy classes. Prepare the format of building labels, including the definition of energy classes. This should include a clear definition of the KPIs used to define the minimum requirements of different energy classes.
- Moderate: Steps 1-4 until 2030: Research and define the appropriate approach to rate and classify the buildings based on their energy classes. Prepare the format of building labels, including the definition of energy classes. This should include a clear definition of the KPIs used to define the minimum requirements of different energy classes. Prepare an implementation plan to introduce the labelling scheme (EPC) on a voluntary basis. This may include a gradual implementation of the labelling scheme. The plan defines clear municipal procedures for issuing the label. Update the auditing process, which might be executed by certified auditors or by the responsible municipality.
- Advanced: Steps 4-5 until 2030: Develop a labelling scheme, possibly based on the existing local certification schemes. Implement the labelling scheme on a mandatory basis for new buildings and a voluntary basis for existing buildings.

4.2.4.5 Building sustainability certification

Definition of activity

Building sustainability certification can be used to verify and enforce performance requirements to enable increased information sharing and documentation for consumers and financial decisions.

Describing sub-roadmap

1. Preparatory steps: If it is not in place, establish a governmental committee or entity to lead and oversee policy of energy efficiency in the buildings sector. Initiate the research phase, including definition of involved stakeholders and formation of working groups or committees such as the technical expert groups to develop the certification scheme.

2. **Strategy and conception:** Prepare the certification scheme covering all building components. This should include clear roles for different involved stakeholders such as the certification body, auditors, and associated training programmes. The accreditation process may also include third parties' verification process (e.g. architect association and energy auditing companies).
3. **Instruments:** Prepare an implementation plan including gradual implementation (e.g. starting with public buildings, then large commercial buildings, large residential buildings, and then residential). The implementation plan may also be initiated focusing on a certain geographic area (e.g. a district or a city). The implementation plan may also include non-financial incentives, which might be in a form of extra floor areas. In this phase the certification scheme is on mandatory basis for new buildings and on voluntary basis for existing building. This step should be accompanied by capacity building activities targeting municipal responsible staff, architects, and building project developers.
4. **Monitoring and reporting:** Monitor the implementation of the pilot phase of the locally developed certification scheme. The monitoring phase should conclude with recommendations to expand the implementation to cover other cities and geographic regions in the country. The monitoring must also include an auditing process , which might be executed by certified auditors from the municipality or from a third party (e.g. energy audit companies and certified consultants). In this step, the certification scheme should be updated to be a mandatory scheme for all building extensions and building retrofit projects.
5. **Evaluation:** Define the gaps and key recommendations to expand the scope of the certification. This should include the update of the scheme, adding new building types , and clear procedural manuals to certify the buildings. The procedures should be prepared with the vision to make it an integral procedure of issuing the construction and occupancy permits for buildings. Establish an effective system to regularly update the certification scheme. The update should aim at more restrictive requirements towards net-Zero buildings. Full enforcement of the certification scheme should be achieved in this step with high penetration of 30-40% in the building stock.

Describing the status quo of tier groups

- **Early Development:** No local certification scheme is in place. It is possible to obtain an international certification for buildings, and low number of buildings have been certified.
- **Moderate Development:** Certifications are not enforced on the building sector. There are different types of voluntary certification schemes
- **Advanced Development:** The buildings guidelines require comprehensive provisions and measures covering energy performance, energy metering, building envelope, renewable energy utilization and energy efficient appliances. Additionally, there are locally elaborated certification schemes. Most of those schemes are well enforced as an integral procedure of issuing the building permits.

Next steps

1. **Early:** Steps 1-2 until 2030: Research and define the appropriate approach to establish a locally adopted building certification scheme. Prepare a locally suitable building

certification including. This should include a clear definition of the KPIs used to define the minimum requirements of energy efficiency.

2. Moderate: Steps 3-4 until 2030: Update the Green Pyramids certification scheme towards more strict energy requirements. The update must include clear municipal procedures for issuing the certification, the auditing, and the verification procedures (through the municipality or by external certified auditors). Prepare an implementation plan to introduce the certification scheme on a mandatory basis. This may include a gradual implementation of the scheme.
3. Advanced: Steps 4-5 until 2030: Establish an effective system to update the existing certification schemes. Define the gaps and key recommendations to expand the scope of the scheme with more restrictive requirements towards net Zero buildings.
4. Moderate Development: No policies are available for considering life cycle analysis of buildings. There is a limited number of education initiative to promote the capacity of professionals in the construction sector about LCA.
5. Advanced Development: The LCA is part of the mandatory rating schemes of the building certificates. Yet, in most of those rating schemes, the life cycle analysis LCA is not mandatory, but they are optional.

4.2.4.6 Energy retrofits plans

Definition of activity

An energy retrofit can be defined as an undertaking of structural, architectural, mechanical, or electrical works with the aim of improving the energy performance of an existing building. While these types of works are rarely carried out for their energy benefits alone, they should become increasingly widespread and be more ambitious in their performance improvement targets. Buildings should be retrofitted as cost-effective as possible to a level in line with long-term energy efficiency and climate targets. This should happen as rapidly as possible, even if the works happen in multiple stages over the course of several years (staged renovation).

Describing sub-roadmap

1. Preparatory steps: Conduct research to identify the approaches to set up a wide-ranging national buildings energy retrofit plan. This should include formation of technical and leading committees, an analysis and assessment of the building stock to define the most suitable retrofit options, energy-saving estimations, and economic analysis considering the cost optimality principles.
2. Strategy and conception: Prepare the national renovation plan. This should include prioritising retrofit options and packages, securing financing options, and setting up energy auditing and performance verification procedures (before and post implementation of retrofit measures). This step can at first focus on certain building types (e.g. public buildings, then high consumers such as commercial buildings, malls, and hotels, then large residential buildings, and finally residential).
3. Instruments: Implement the renovation plan including gradual implementation (e.g. starting with large consumers such as public buildings and malls, then on a voluntary basis for the large residential buildings). The implementation plan may also be initiated focusing on a certain geographic area (e.g. a district or a city).

4. **Monitoring and reporting:** Monitor the implementation of the pilot phase renovation plan. The monitoring phase should conclude with recommendations to expand the implementation to cover other cities and geographic regions in the country. Update the retrofit options (packages) to have higher energy savings and to cover other building types. The monitoring and reporting of the implementation of energy retrofit plans should be collected in a database. Such a database will enable the municipalities and cities to monitor the energy performance, define key gaps, and set recommendations to improve energy retrofit plans at the city level. This is to be executed in cooperation with other relevant stakeholders such as electricity and energy providers, energy auditors, building project developers, and owners.
5. **Evaluation:** Define the gaps and key recommendations to expand the scope of the building retrofit national plan. Update the retrofit options (packages) to achieve the savings of net Zero buildings. Adopt regulations for a regular retrofit of buildings (e.g. 10 years or based on the results of regular energy audits).

Describing the status quo of tier groups

- **Early Development:** No activity in building retrofits is available.
- **Moderate Development:** No policies are available on the retrofits. Retrofits are only mentioned in the code for energy efficiency of residential buildings without the coverage in the code for commercial buildings. The code is mandated but not enforced for application.
- **Advanced Development:** No official policies are available as mandatory for retrofitting buildings. No thresholds are mandatory for retrofitting..

Next steps

- **Early Development: Steps 1-3 until 2030:** Set up a wide national renovation plan. This should include the formation of technical and leading committees, an analysis assessment of the building stock, definition of retrofit options, energy-saving estimations, economic analysis considering the cost optimality principles, secure financing options, and setting up energy auditing and performance verification procedures (before renovation and post occupancy). Start a gradual implementation of the national renovation plan.
- **Moderate Development: Steps 1-3 until 2030:** Set up a wide national renovation plan. This should include the formation of technical and leading committees, an analysis assessment of the building stock, definition of retrofit options, energy-saving estimations, economic analysis considering the cost optimality principles, secure financing options, and setting up energy auditing and performance verification procedures (before renovation and post occupancy). Start a gradual implementation of the national renovation plan.
- **Advanced Development: Steps 4-5 until 2030:** Evaluate the current renovation plans and programmes. Conclude with recommendations to expand the implementation to cover other building types, cities, and geographic regions in the country. Update the retrofit options (packages) with inspiration for net-zero levels.

4.2.4.7 Energy audits for existing buildings

Definition of activity

Energy audits are powerful tools to assess opportunities to optimise efficiency in operation (parameter adjustment) and to identify effective energy-saving measures. Energy audits should be performed regularly, particularly in buildings with high energy consumption.

Describing sub-roadmap

1. Preparatory steps: Perform an examination to determine the buildings with the highest expected saving potentials of energy audits (parameters: Individual building cost-benefits and share of the building stock consumption). In this step, capacity building and raising awareness programmes should be prepared. Such programmes are to focus on raising awareness among architects, engineers, and building project developers. Ultimately, energy auditor certification programmes should be developed if not in place.
2. Strategy and conception: Identify and provide locally suitable auditing tools, material, and procedures. This step may at first focus on certain building types (e.g. public buildings, then high consumers such as commercial buildings, malls, and hotels, then large residential buildings, and finally residential).
3. Instruments: Set up effective mechanisms—either regulations (for buildings with profitable saving potentials or acceptable effort), grant schemes (for buildings with non-profitable but relevant saving potentials), or information campaigns (for buildings with highly profitable but not publicly aware saving potentials) to enable energy audit at the most relevant buildings. The mechanisms should be in line with international standards, specifically with the ISO 50001. The implementation plan may also be initiated focusing on a certain geographic area (e.g. a district or a city). The gradual implementation may start with covering certain components of the building. This step should be accompanied by capacity building activities targeting municipal responsible staff, architects, and building project developers.
4. Monitoring and reporting: Monitor the implementation to conclude with recommendations to update the mechanism and expand it to cover other building types and other areas. Create a database to monitor the achievements.
5. Evaluation: Regularly check and adapt the mechanisms. The update should aim towards net-zero requirements. The energy audits should be established as regular procedures for all buildings (e.g. every 10 years or when necessary for renovation and refurbishment projects).

Describing the status quo of tier groups.

- Early Development: No energy audit actions are taking place.
- Moderate Development: No energy audits are available. Only benchmarking was applied.
- Advanced Development: The building owner must enter into a service contract with a maintenance company approved by the utility provider or provide evidence that equipment will be properly maintained by competent members of their own staff. Few ESCO provides an energy audit based on calculations, energy bills, and energy surveys, clarifying possible retrofit points and decreasing the carbon footprint without affecting the final output for the building operations. Next steps

- **Early Development: Steps 1-3 until 2030:** Perform an examination to determine the buildings with the highest expected saving potentials from energy audits. Identify and, when necessary, develop and provide suitable auditing tools, material, and procedures. Set up effective mechanisms—either regulations (for buildings with profitable saving potentials or acceptable effort), grant schemes (for buildings with non-profitable but relevant saving potentials), or information campaigns (for buildings with highly profitable but not publicly aware saving potentials) to enable energy audits at the most relevant buildings. The mechanisms should be in line with international standards, specifically ISO 50001.
- **Moderate Development: Steps 1-3 until 2030:** Perform an examination to determine the buildings with the highest expected saving potentials from energy audits. Identify and, when necessary, develop and provide suitable auditing tools, material, and procedures. Set up effective mechanisms—either regulations (for buildings with profitable saving potentials or acceptable effort), grant schemes (for buildings with non-profitable but relevant saving potentials) or information campaigns (for buildings with highly profitable but not publicly aware saving potentials) to enable energy audits at the most relevant buildings. The mechanisms should be in line with international standards, specifically ISO 50001.
- **Advanced Development: Steps 4-5 until 2030:** Revise and update the energy audit mechanisms and policies. The update should be towards achieving net-zero. Energy audits should be mandatory for all buildings and be executed on a regular basis (e.g. every 10 years or with renewal of building passport and certification).

4.2.4.8 Sub-conclusion

The design and implementation of policy instruments to govern the buildings sector towards a sustainable future should follow the steps of policy process development. The process includes:

- Preparatory steps including problem definitions and setting the targets
- Strategy and conception of the policy options
- Policy instrument implementation
- Monitoring and evaluation to update the policy instruments and the relevant targets.

Figure 20 and Figure 21 show the main (aggregated) steps to decarbonise the policy for Activities 2 and 3. The bottom of each figure illustrates the mapping of the three different development phases and the upper half shows the recommended steps.

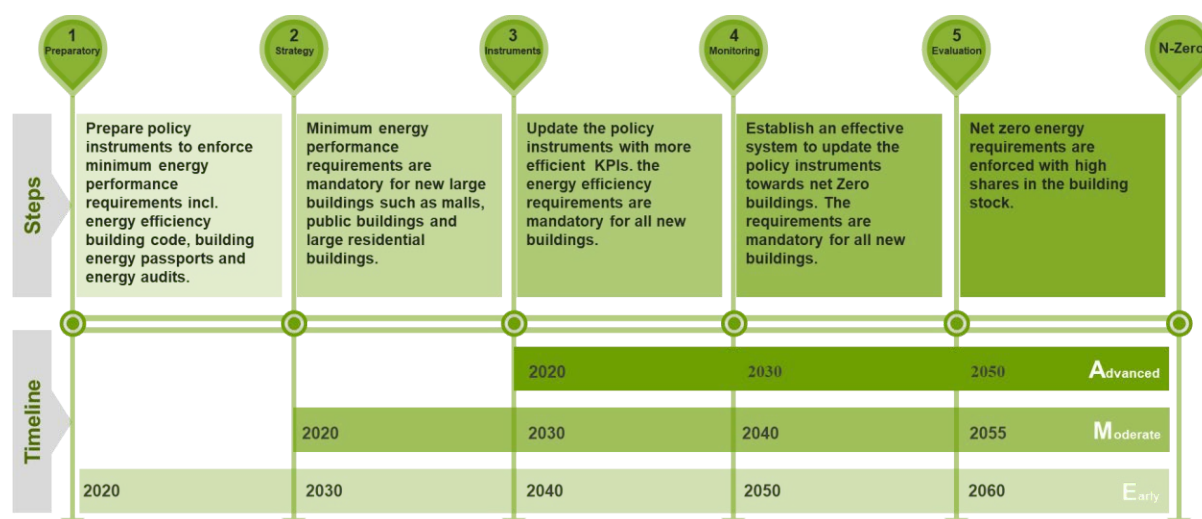
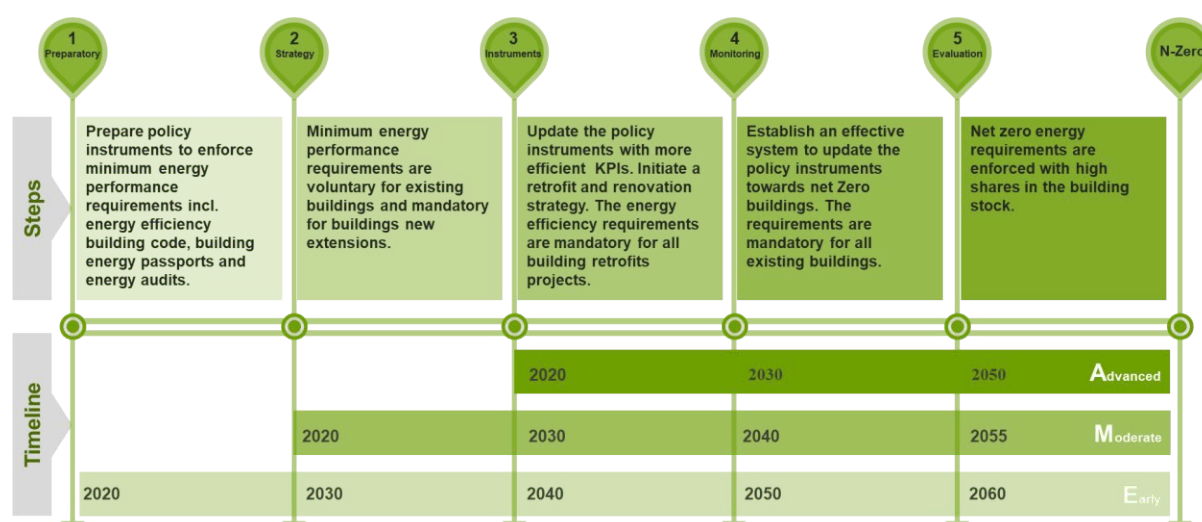


Figure 20. Roadmap for Activity 2 – new buildings, policy.



The different steps for the evolution of policy instruments governing energy efficiency. Start focusing on new buildings, then update the thresholds of existing buildings.

Figure 21. Roadmap for Activity 3 – existing buildings, policy.

4.2.5 Technology for sustainable new buildings and building retrofits

The energy use and emissions from new buildings are influenced by their design, choice of technologies, and materials. The first phase of building design should be to reduce the amount of energy the building requires to operate. Sustainable technology for new buildings and building retrofits include several aspects such as passive design, external shading, air tightens, and design tools. The status quo of those technologies and the roadmap towards more sustainable buildings are discussed in the following sections.

4.2.5.1 Passive design

Definition of activity

Strategies for the most cost-effective combination of thermal performance of the building fabric, control of solar gains and ventilation, and daylight are highly dependent on the building type, how it will be used, and the macro- and microclimate in which it is situated. Therefore, passive design strategies must be developed for specific bioclimatic regions and specific

building types. These locally adapted design guidelines can ensure that passive strategies can be optimised before relying on active systems. Passive design measures for existing buildings may include the same topics with special considerations in a form of guidelines specific to the retrofit and refurbishments of existing buildings.

Describing sub-roadmap

1. Research and study to conclude guidelines of passive design techniques of the buildings. Such guidelines should consider the different types of buildings, different sizes, and different climatic zones in the country.
2. The passive design guidelines are introduced to be implemented in on a voluntary basis, possibly with non-fiscal incentives if certain energy savings are to be achieved.
3. All new buildings to comply with the passive design measures as discussed in the guidelines. Widespread knowledge building on passive design is to be achieved in this step.
4. Update the guidelines to cover the existing buildings. All extensions of existing buildings and renovation of existing buildings to comply with the possible passive design measures as set out in the guidelines. The possible measure may include shading, daylighting, and natural ventilation.

Describing the status quo of tier groups

- Early Development: No actions in the field of passive design are taking place.
- Moderate Development: The application of passive design methods is covered in several studies and research, but no policy instruments found to be fully.
- Advanced Development: Code provides the maximum allowable requirements for the thermal transmittance of the building envelope (external walls, roofs, and exposed floors (the underside of the floor)). In the mandatory building rating schemes, passive design measures are not required but rather are rewarded with points when achieving energy reductions in annual external heat gain attributed to passive design measures using the enhanced U-values, solar heat gain coefficient (SHGC), infiltration rates, etc.

Next steps

- Early Development: Steps 1-3 until 2030: Preparation of guidelines of passive design techniques considering the different types of buildings and different climatic zones. All new buildings to comply with the possible passive design measures as elaborated in the guidelines.
- Moderate Development: Steps 1-3 until 2030. Preparation of guidelines of passive design techniques considering the different types of buildings and different climatic zones. All new buildings to comply with the possible passive design measures as elaborated in the guidelines.
- Advanced: Step 3 until 2030: Update the passive design guidelines provided in the mandatory building rating schemes. The compliance with passive design measures should be required, not rewarded. All extensions of existing buildings and renovation of existing buildings to comply with the possible passive design measures as elaborated in the building rating schemes.

4.2.5.2 Building envelope (U-value)

Definition of activity

Insulation is one of the components of overall thermal transfer value (OTTV) that should have specific targets for hot locations and cold locations. A material's insulation performance is determined by its thermal conductivity. U-value is also commonly used to express how much heat will transfer through a given thickness of a particular material, where the lower the U-value, the better the material is as an insulator. Insulation is important in hot climates and in cold climates and is most effective in the component of greatest surface area (i.e. the roof for low and flat buildings, walls for tall buildings). Note: it is beneficial to assess the benefits of increased insulation over a whole lifecycle carbon assessment, given the comparatively high embodied carbon of traditional insulating materials (IEA, 2013b).

Describing sub-roadmap

1. Research and evaluate the local construction practices of insulation materials and building envelopes. This is to determine the current efficiencies of the different insulation materials available in the construction sector in the country. Such research should conclude a clear strategy for the provision of appropriate insulation materials in the construction market. The strategy should consider the cost optimality principles and the local economic conditions.
2. All new buildings and extensions of existing buildings fulfil the minimum U-values proposed in the local EEBCs.
3. All existing buildings renovations and refurbishments projects must fulfil the minimum U-values proposed in the local EEBCs.
4. Strengthen and increase the efficiencies of U-values of all new buildings, extensions of existing buildings, and renovation projects. Widespread knowledge and availability for optimising building envelope is to be achieved in this step.
5. Develop more restrictive U-values for net-zero energy buildings. The used insulation should have reduced the embodied energy and comply with the LCA standards.

Describing the status quo of tier groups

- Early Development: No energy efficiency code is in place. Therefore, no activities are available related to insulation.
- Moderate Development: Energy Efficiency Building Codes covering the point of insulation for new buildings. Codes mentions required R-value.

Advanced Development: Recommends the use of insulation for the building envelope instead of just achieving the minimum envelope requirements using aerated concrete blocks. The code also provides the maximum allowable requirements for the thermal transmittance of the building envelope (external walls, roofs, and exposed floors (the underside of the floor)). The average thermal transmittance of roofs and for external walls and exposed floors shall not exceed 0.3 W/m²K and 0.57 W/m²K, respectively. And codes even encourage lower U-values of 0.2 W/m²K for roofs.

Next steps

- Early Development: Steps 1-2 until 2030: Research and evaluate the local construction practices of insulation materials and building envelopes to conclude a clear strategy for

the provision of appropriate insulation materials in the construction market. All new buildings (and extensions of existing buildings) must fulfil the minimum U-values as proposed in EEBCs.

- Moderate: Steps 1-3 until 2030: All new buildings, extensions of existing buildings, and refurbishment projects must fulfil the minimum U-values proposed in the local energy efficiency building codes.
- Advanced: Step 4 until 2030: Develop more restrictive U-values for zero energy buildings. The used insulation should have reduced the embodied energy and comply with the LCA standards.

4.2.5.3 External shading

Definition of activity

External shading in the form of horizontal, vertical, fixed, or movable elements can be the most cost-effective method of blocking out solar radiation. Good shading can have the same effect on reducing the solar heat gain coefficient (SHGC) of windows as solar-performance glazing. The optimisation of building orientation must also be considered; for that, it is recommended to use simulation tools (e.g. BEopt™ Building Energy Optimization Tool, eQUEST, EnergyPlus, DesignBuilder, Trnsys) to define the optimum orientation that provides the optimum shading and hence reduce the cooling demand.

Describing sub-roadmap

1. Research and study to conclude guidelines (or standards) of external shading techniques of the buildings. Such guidelines should consider the different types of buildings, different sizes and different climatic zones in the country.
2. The external shading guidelines (or standards) are introduced to be implemented on a voluntary basis in new and existing buildings.
3. All new buildings to comply with the external shading measures as elaborated in the guidelines or as part of a standard and the EEBC.
4. Update the guidelines to cover the existing buildings. All extensions of existing buildings and renovation of existing buildings to comply with the possible passive design measures as set out in the guidelines (or standards).

Describing the status quo of tier groups

- Early Development: No actions in the field of external shading are taking place in these countries.
- Moderate Development: The building Energy Efficiency Codes cover the external louvered shutter or roller blinds; awnings, overhangs, and vertical fins; and other external shading devices. SHGC for fenestration would be eliminated if the roller blinds or shutters block 90% of the fenestration area. It would be relaxed for awnings, overhangs, and vertical.
- Advanced Development: The Building Code takes into consideration the impact of external shading (where used) and adjacent buildings can be taken into account when calculating external load criteria using the performance method.

Next steps

- Early Development: Steps 1-3 until 2030: Prepare guidelines (or standards) for external shading techniques considering the different types of buildings and different climatic zones. All new buildings to comply with the external shading measures as drafted in the guidelines.
- Moderate Development: Steps 2-3 until 2030: Update the provisions of external shading in the EEBCs. Prepare the municipal procedures to enforce the compliance with external shading measures in all new buildings.
- Advanced: Step 3 until 2030: Update the external shading guidelines provided in the mandatory building rating schemes. The compliance with external shading guidelines should be required not rewarded. All extensions of existing buildings and renovation of existing buildings to comply with the external shading guidelines measures as drafted in the building rating schemes. External shading technologies must consider the local LCA standards.

4.2.5.4 Reducing solar gains using reflective surface and windows**Definition of activity**

Light-coloured surfaces or surfaces with reflective pigments reflect incoming solar radiation, reducing the temperature of the surface. Reflective surface finishes are most effective on the surfaces most exposed to direct sunlight, which typically will be the roof. Painting building surfaces can also be an effectively and relatively low intrusion retrofit measure.

Describing sub-roadmap

1. Research and study to conclude guidelines of light-coloured surfaces and surfaces with reflective pigments. Such guidelines should consider the different types of buildings, different sizes, and different climatic zones in the country. The guidelines should clearly define a KPI such as the material's specification and possibly the Albedo of the surfaces.
2. Light-coloured surfaces and surfaces with reflective pigments guidelines are introduced to be implemented on a voluntary basis.
3. All new buildings to comply with the light-coloured surfaces and surfaces with reflective pigments measures as set out in the guidelines.
4. Update the guidelines to cover the existing buildings. All extensions of existing buildings and renovation of existing buildings to comply with the possible light-coloured surfaces and surfaces with reflective pigments measures as set out in the guidelines or in the EEBC.
5. Widespread knowledge and use of the appropriate light-coloured surfaces and surfaces with reflective pigments. High penetration of light-coloured surfaces and reflective surfaces in the building stock.

Describing the status quo of tier groups

- Early Development: No provisions in place.
- Moderate Development: Based on the building codes, the required external surface absorptivity ranges between 0.38 and 0.7 (α) depending on the facades and orientations.

- **Advanced Development:** The Building Code, the reflective surfaces are not required but rather rewarded with points when achieving energy reductions in annual external heat gain attributed to passive design measures using the enhanced U-values, SHGC, infiltration rates, etc.

Next steps

- **Early Development:** Steps 1-3 until 2030: Prepare guidelines (or standards) for light-coloured surfaces and surfaces with reflective pigments considering the different types of buildings and different climatic zones. All new buildings to comply with the light-coloured surfaces and surfaces with reflective pigments as set out in the guidelines.
- **Moderate Development:** Steps 2-3 until 2030: Update the provisions of external shading in the EEBCs. Prepare the municipal procedures to enforce the compliance with external shading measures. All new buildings, all renovations projects, and existing building extension projects to comply with the standards (provisions in the EEBC) of the light-coloured surfaces and surfaces with reflective.
- **Advanced:** Step 3 until 2030: Update the provisions of surfaces in the mandatory building rating schemes. The compliance with surfaces requirements should be required not rewarded. All extensions of existing buildings and renovation of existing buildings to comply with the surfaces requirements as set out in the building rating schemes. The surface materials must comply with the local LCA standards.

4.2.5.5 Windows (solar and thermal characteristics)

Definition of activity

The dominant source of heat transfer through windows is through solar radiation. This can be reduced with low-e and low-SHGC windows. Building design and advanced technologies can enable low solar heat gain during hot weather, while allowing visible light transmittance for natural daylighting; however, the most cost-effective way of avoiding excess solar gain is reducing the size of windows and providing shading. Furthermore, heat transfer by conduction through glazing can be reduced through a transition to double- or triple-pane glazing, which has lower thermal transmittance, or U-value. When produced at scale, these types of windows can be cost-effective. These windows also provide noise protection, improve thermal comfort, and can enable passive architecture and natural ventilation. Note: the benefits of double- or triple-pane glazing should be assessed through a cost-benefit analysis over the whole lifecycle (for example, using building simulation tools), also assessing the impact on embodied carbon given the high materials and energy costs of glass manufacturing.

Describing sub-roadmap

1. **Preparatory steps:** Research and evaluate the local construction practices of the building windows. Study and define the best available low-e and low-SHGC windows in the local market. Such research should conclude a clear strategy for upscaling of windows with appropriate solar and thermal specifications in the construction market. The strategy should consider the cost optimality principles and the local economic conditions.
2. **Strategy and conception:** Set up independent technical expert groups to define a list of locally appropriate thermal and solar specifications of windows (a standard). This may include but is not limited to window technology catalogues and construction guidelines.
3. **All new buildings to comply with the window thermal and solar specifications as set out in the guidelines (or standards).**

4. Update the guidelines (standards) to cover the existing buildings. All extensions of existing buildings and renovation of existing buildings to comply with the specification of windows measures as set out in the guidelines or in the EEBC.
5. Widespread knowledge and use of the thermal and solar specifications. High penetration of efficient windows in the building stock.

Describing the status quo of tier groups

- Early Development: No energy efficiency code is available; therefore, no activities are available related to windows (solar).
- Moderate Development: Reflective surfaces are not mentioned in the building code for the case of the roof or the envelope. Values for SHGC for windows are mentioned.
- Advanced Development: Reflective surfaces are not mentioned in the Building Code, only the criteria for glazed elements are covered. Only the average thermal transmittance (W/m^2K) for a roof is mentioned to be less than or equal to 0.3. The code also defines the performance criteria for glazing vertical surfaces that must be met based on a WWR.

Next steps

- Early Development: Steps 1-3 until 2030: Prepare guidelines (or a standards) for windows with low-e and low-SHGC (windows solar and thermal requirements) considering the different types of buildings and different climatic zones. All new buildings to comply with the windows requirements established in the guidelines.
- Moderate Development: Steps 2-3 until 2030: Update the provisions of windows with low-e and low-SHGC in the EEBCs (windows solar and thermal requirements). Prepare the municipal procedures to enforce the compliance with windows with low-e and low-SHGC requirements. All new buildings, all building retrofit projects, and existing building extension projects to comply with the requirements. High penetration of efficient windows is achieved in the buildings sector.
- Advanced: Step 3 until 2030: Update the provisions of thermal and solar requirements of windows in the mandatory building rating schemes. The compliance with windows requirements should be required, not rewarded. All extensions of existing buildings and renovation of existing buildings to comply with window solar and thermal requirements. The window specifications must comply with the local LCA standards.

4.2.5.6 Daylighting

Definition of activity

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

Describing sub-roadmap

1. Step 1: Preparatory steps: Research and evaluate the local construction practices of daylighting and standards (if any). Study and define the best available practices. Set up

independent technical expert groups to define the appropriate daylighting guidelines including minimum WWRs. This can be part of the EEBC (if any) or in the building code.

2. Step 2: All new buildings to comply with the daylighting guidelines established in the guidelines (or in the EEBC).
3. Step 3: Update the guidelines (standards) to cover the existing buildings. All extensions of existing buildings and renovation of existing buildings to comply with the daylighting guidelines as in the EEBC.
4. Widespread knowledge and practice of optimised daylighting measures. Most of the buildings fulfil the daylighting guidelines.

Describing the status quo of tier groups

- Early Development: No energy efficiency code is available; therefore, no activities are available related to daylighting. Only individual practices are available.
- Moderate Development: Based on the building codes to permit the use of daylighting, kitchens and living rooms must have:
 - Angle of obstruction (X) not greater than 800 (measured from the centre of a vertical window).
 - Minimum WWR must be at least: 8% for kitchens, 15% for living rooms
 - Glass type must have visual lighting.
 - Transmittance (VLT) at least 0.45.
 - Internal surface colours for walls and ceiling must be:
 - For kitchens, light, but not medium or dark.
 - For living rooms, light or medium, but not dark.
 - SHGC varies from 0.61 to 0.81 according to the type of glass, while VLT varies from 0.53 to 0.9.
- Advanced Development: The Building Code ensures the provision of adequate daylighting by defining the minimum allowable window glazing area (percentage of window net glazing area to room area). For all occupancy levels (business, residential and hotel, educational and assembly) the minimum window glazing area shall be over 10%. Furthermore, the room depth should not exceed three times the width of the wall the window is located. If it exceeds, suitable daylighting must be provided through additional windows along any of the other sides that have direct access to daylighting.

Next steps

- Early Development: Steps 1-3 until 2030: Prepare guidelines (or a standards) for daylighting including minimum WWRs and considering the different types of buildings and different climatic zones. All new buildings to comply with the suggested guidelines (which might be part of EEBC).
- Moderate Development: Steps 2-3 until 2030: Update the provisions of daylighting in the EEBCs. To prepare the municipal procedures to enforce the compliance with external shading measures. All new buildings, all renovations projects, and existing building extension projects to comply with the daylighting requirements.

- **Advanced: Step 3 until 2030:** Update the provisions of daylighting in the building code to ensure optimisation of daylighting. The requirements to be enforced for all new buildings, all renovations projects, and existing building extension projects.

4.2.5.7 Air tightness

Definition of activity

Airflow into buildings through uncontrolled openings can be harmful to occupants' health, can reduce comfort, and can increase energy use. To achieve passive heating and cooling, the industry saying of "build it tight and ventilate it right" starts with removing any uncontrolled airflow through improved air tightness. The targets move toward less than one air change per hour (ACH) at 50 PA air pressure. Some air tightness standards set the metric with $\text{m}^3/\text{h} \times \text{m}^2$ at 50 PA, which is good to identify the air permeability of the building surface but can cause a lack of comparability from an energy or occupant perspective between two buildings of the same size and same volume, simply by having a different shape and a different surface area. Air barriers can be created using membranes, foams, liquid coatings, and properly sealed windows.

Describing sub-roadmap

1. Preparatory steps: Research and evaluate the local construction practices of uncontrolled airflow and air tightness levels and standards and standards (if any). Study and define the best available practices. Set up independent technical expert groups to define the appropriate air tightness levels and standards. This can be part of the EEBC (if any) or in the building code.
2. All new buildings to comply with the optimum tightness levels as set out in the guidelines (or in the EEBC).
3. Update the guidelines (standards) to cover the existing buildings. All extensions of existing buildings and renovation of existing buildings to comply with the tightness optimum levels.
4. Widespread knowledge and use of tightness levels. Most of the buildings fulfil the optimum tightness retirements.

Describing the status quo of tier groups

- **Early Development:** Actions are not taken related to the technology of air tightness.
- **Moderate Development:** The infiltration of site fabricated, or prefabricated fenestration must be determined by an accredited, independent laboratory and labelled and certified by the manufacturer or the manufacturer must certify that the fenestration is installed per the following maximum allowed infiltration rates: 1. For sliding doors, 1.8 litre per second per square meter of window area. (L/s/m^2); 2. For swinging doors, 3.0 litre per second per square meter of window area. For the sealing of other components of the building, no values were mentioned as a threshold or a range.
- **Advanced Development:** The Building Code, sets the maximum allowable air leakage in or out of the building for air-conditioned buildings with a cooling load of 1 MW or greater to not exceed $5 \text{ m}^3/\text{h/m}^2$ at an applied pressure of 50 Pa. Air tightness testing shall be carried out to verify compliance, in accordance with BS EN 13829 or ASTM E779 or as approved by the authority. A lobby or a door barrier system shall be used to mitigate potential loss of conditioned air from a main entrance to an air conditioned building.

Next steps

- Early Development: Steps 1-3 until 2030: Prepare guidelines (or standards) of air tightness considering the different types of buildings and different climatic zones. All new buildings to comply with the suggested guidelines (which might be part of EEBC).
- Moderate Development: Steps 2-3 until 2030: Update the provisions of airtightness in the EEBCs. To prepare the municipal procedures to enforce the compliance with the optimised air tightness requirements. All new buildings, all renovations projects, and existing building extension projects to comply with the requirements.
- Advanced Development: Step 3 until 2030: Update the requirements of air tightness in the building code to ensure the optimisation of air leakage levels. The update should be according to net-zero levels. The requirements to be enforced for all new buildings, all renovations projects, and existing building extension projects.

4.2.5.8 Design tools**Definition of activity**

The integrated design process of involving all disciplines of a building project (e.g. architect, lighting engineer, structural engineer, facilities manager, etc.) from the early stages of the project enables the adoption of many more passive design measures than when disciplines are brought on at later stages. Other tools with significant potential to optimise passive measures and design choices include thermal and energy dynamic simulation, daylight simulation, and building information modelling (BIM).

Describing sub-roadmap

1. Preparatory steps: Research and evaluate the locally used and available design tools covering the topics of thermal and energy dynamic simulation, daylight simulation, and BIM. Set up independent technical expert groups to define a list of locally appropriate building energy efficiency modelling tools. Adopt a set of locally suitable building energy efficiency modelling tools.
2. Instruments: Prepare guidelines to use locally appropriate building energy efficiency modelling tools. To prepare a BIM code covering the energy efficiency of buildings.
3. Introduce BIM code, energy dynamic simulation, and daylight simulation tools to be used on a voluntary basis. This is to be accompanied by a capacity building programmes for building designers, architects, and engineers.
4. Widespread knowledge about using the BIM building energy efficiency modelling and simulation tools.
5. Using BIM building energy efficiency modelling and simulation tools is a fundamental part of the architecture and construction practice. Submission of the simulation, modelling of buildings design is an integral part of the construction documents to be submitted to obtain the construction permits.

Describing the status quo of tier groups

- Early Development: Design tools are not available.
- Moderate Development: The building energy simulation is available on the scale of research, but the physical implementation is limited. BIM code has been issued as a voluntary code, but it does not focus on energy efficiency and sustainability.

- **Advanced Development:** MOEI sustainability guideline suggests using an appropriate dynamic energy modelling software to develop the energy model. National rating schemes such as the Pearl Rating System suggest using appropriate design tools and specifies the calculation methodology to calculate the performance and efficiencies of building components and systems. Dubai prescribed the implementation of BIM. Based on the Dubai Municipality's Circular No. 196 of 2013 and its updated of 2015, BIM code is required for certain building types such as buildings above 20 floors, facilities and compounds with areas larger than 200,000 square feet, buildings and special facilities such as hospitals and universities and all government projects.

Next steps

- **Early Development:** Steps 1-3 until 2030: Research and evaluate the locally used and available thermal and energy dynamic simulation, daylight simulation, and BIM. Adopt a set of locally suitable building energy efficiency modelling tools. Prepare guidelines to use locally suitable building energy efficiency modelling tools and develop a BIM code covering the energy efficiency of buildings. This is to be accompanied by a capacity building programmes for building designers, architects, and engineers.
- **Moderate Development:** Steps 2-4 until 2030: Research and adopt a set of locally suitable and available thermal and energy dynamic simulation, daylight simulation, and BIM. Prepare a BIM code covering the energy efficiency of buildings. Update the voluntary BIM code to include energy efficiency aspects. The BIM code and energy dynamic simulation and daylight simulation tools are introduced to be used on a voluntary basis. This is to be accompanied by a capacity building programmes for building designers, architects, and engineers. Spread knowledge widely about using the BIM building energy efficiency modelling tools and simulation tools.
- **Advanced:** Step 5 until 2030. Update the BIM code to include energy efficiency aspects. Make energy efficiency modelling tools and simulation tools a fundamental part of the architecture and construction practice. Submission of the simulation, modelling of building design is an integral part of the construction documents to be submitted to obtain the construction permits.

4.2.5.9 Sub-conclusion

Figure 22 and Figure 23 show the main (aggregated) steps to decarbonise the technology for Activities 2 and 3. The bottom half of each figure illustrates the mapping of the three different development phases and the upper half shows the recommended steps.

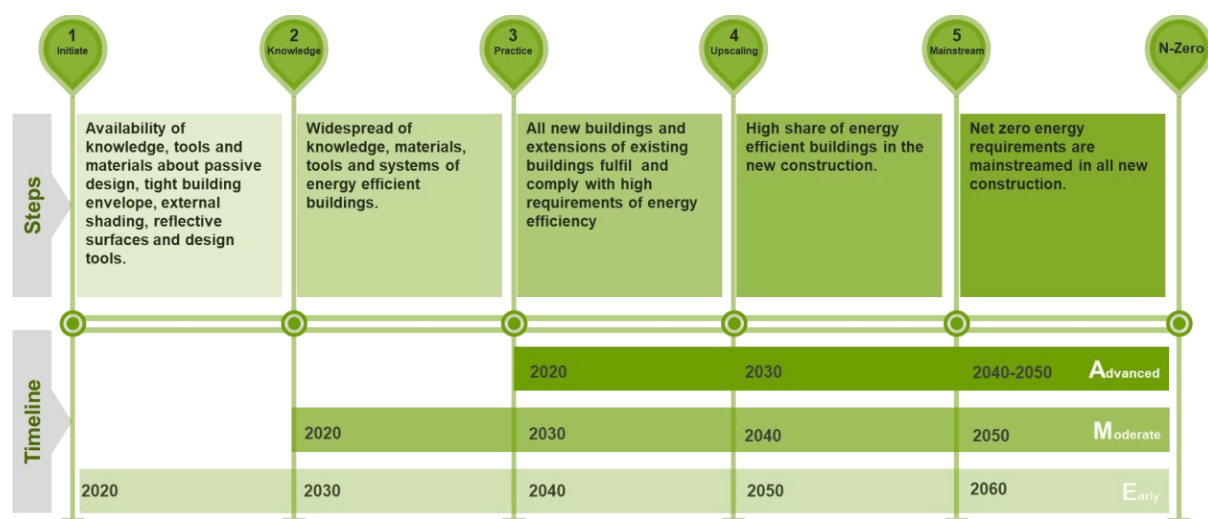
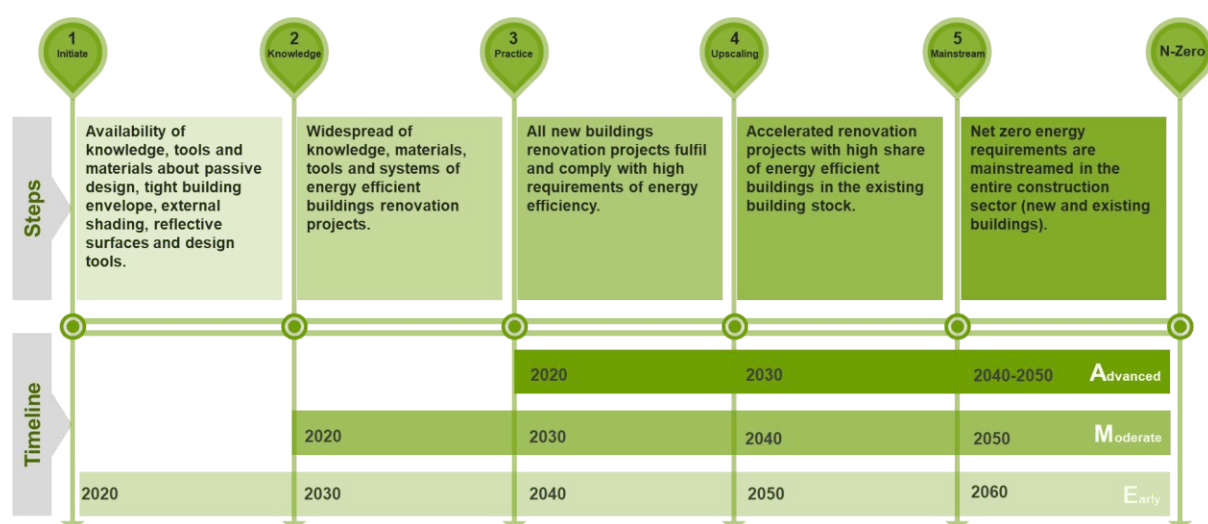


Figure 22. Roadmap for Activity 2 – new buildings, technology.



The transition towards sustainable buildings is initiated by providing the knowledge, the tools, materials and systems required.

Figure 23. Roadmap for Activity 3 – existing buildings, technology.

4.2.6 Best practices (new buildings)

Policy/Planning: Instruments and codes for building energy efficiency, Germany

Development of Energy-saving Construction

Primary energy need semi-detached house – Heating [kWh/m²a]

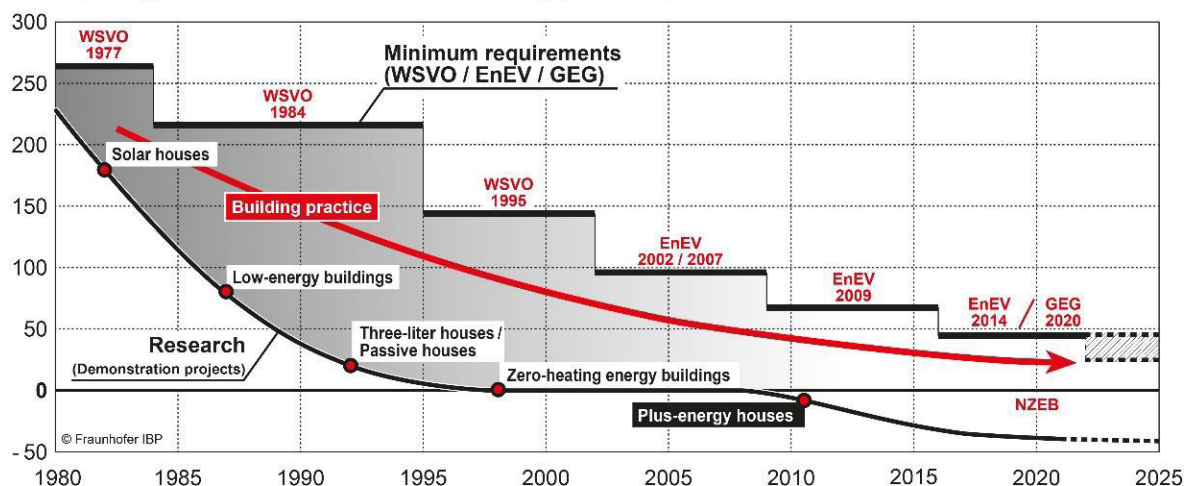


Image © Fraunhofer IBP

The energy efficiency requirements of single-family houses in Germany have developed from 250kWh/m²a in 1977 to reach less than 50kWh/m²a in 2020. A regular update of its energy efficiency building code was accompanied by a series of demonstration projects and incentive programmes.

Technology/Implementation: Siemens HQ in Masdar City, Abu Dhabi Development



DFEC (Masdar) built Siemens Headquarters in 2013. The main measures to save energy are a solar thermal collector on the roof, a mechanical ventilation system with heat recovery, a highly insulated, airtight inner façade that reduces thermal conductivity, and lightweight aluminium external shading that minimises solar gain and maximises daylight. The building performs 46% better than the baseline American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) energy model.

4.2.7 Best practices (retrofit)

Policy/Planning: Energie Sprong Principle, Germany



Energiesprong principle relies on a digitised construction process, high quality, standardised solutions with prefabricated elements, and a long-term promise of performance. Energiesprong stands for refurbishment to the net-zero standard, high living comfort, short renovation times, and an innovative financing model.

Source: Energiesprong, Germany ([link](#))

Technology/Implementation: Wasl Properties Retrofit, Dubai – UAE



Image credits: Drone shot by Hennie Schoeman, Installation of the PV system by TerraStruc Energy Services. Wasl Properties Retrofit in cooperation with Etihad Energy Service implemented a large-scale retrofit project that has achieved more than 25% of energy savings compared to before retrofit. That was equal to 14,429 tons of CO₂. (Source: Etihad Energy Service ([link](#)))

4.3 Activity 4: Building operations

Beyond improving the quality of building systems, their proper operation is essential to confirming the potential savings are achieved in practice, not just on paper. This presumes a proper installation, optimised system parameter settings, sufficient maintenance (like regular filter exchanges), and adequate behavioural matters significantly impact the energy and GHG performance of buildings. Leveraging operational potential requires technical equipment like energy meters and smart controls as well as organisational structures and staff that ensure that actions to improve performance take place. Objective-based building management policies (e.g. ISO 50001) or operations guides are good examples of tools that can improve building operations.

4.3.1 Key actions for sustainable building operations

Leveraging the potentials of improved-or even optimal building operation is a challenge for all countries, not only the Arab region. The following lists three key actions for all countries:

Key actions for improved building operations for all countries should include:

- Initialise an analysis of gaps and potentials to identify the most relevant building types with the highest potential for an improved operation as well as the overall savings potential in relation to other measures.
- Develop suitable options of political actions to tackle the specified potentials including corresponding surveillance mechanisms and incentives (including installer declarations, obligations for certification of regular system inspections, and operational certificates).
- Implement the identified most promising options.

4.3.2 Stakeholders for sustainable building operation

In the Arab region, the key stakeholders for existing building operations include those that can influence existing buildings and those that can deliver the results of low-emissions, efficient, and resilient buildings through operations. Additional stakeholders include those that can support the process through research, funding, training, and making technologies available. All of these stakeholders are essential to delivering on roadmap targets. Table 4 shows the stakeholders; the darker the colour of the cell, the more relevant the stakeholder is. The key stakeholders are marked in bold.

Table 4. Stakeholders for sustainable building operation.

Stakeholders	
National government	Sustainable service providers / Facility Managers
Subnational government	Civil society
Implementing and enforcement agencies/actors	Sustainable product/material providers
Building authorities and housing associations	Researchers
Architects and engineers	Financial institutions
Building owners	Training and capacity institutions/providers
Utility companies and municipal service authorities	Business associations

4.3.3 Policy for sustainable building operation

Specifically, targeted policies can enable improved building operation to ensure that the buildings unfold their full potential regarding low-emission, efficiency, and resilience. Policies for an improved building operation can address different relevant items like proper

commissioning, regular maintenance, optimisation during operation based on long-term monitoring, or just behavioural changes. Within the targets for sustainable building operations, the following sub-activities offer more details.

4.3.3.1 Certification for operational performance

Definition of activity

Obligatory or voluntary certification can be an appropriate measure to improve the operational performance of buildings. Certifications can be requested and provided for proper installation and commissioning regular maintenance and system optimisation. An appropriate international certification scheme is the LEED certification for Operations and Maintenance.

Describing sub-roadmap

1. Analysis of gaps and potentials to identify the most relevant building types with the highest potential for an improved operation as well as the overall savings potential in relation to other measures.
2. Develop suitable options of political actions to tackle the specified potentials including corresponding surveillance mechanisms. Options should include installer declarations for correct installation and commissioning and obligations of/or certification of regular system inspections (including maintenance and optimisation) and operational certificates for overall energy demand. Evaluate the expected effects of the options with consideration of the specific national situation.
3. Develop and implement the identified most suitable instruments and set up a system to monitor the successes.
4. Evaluate the monitoring and adapt the instruments.

Describing the status quo of tier groups

- Early Development: No certifications for building operations are available.
- Moderate Development: Building's green certifications include section related maintenance and operation covering different building operations.
- Advanced Development: Green building certifications encourage innovation to achieve integration between green systems and technologies in building design, which is reflected in improving performance, reducing energy consumption, increasing the efficiency of electrical and mechanical systems, and therefore reducing the carbon footprint. The system of the certification operates based on the fulfilment of a set of criteria to be certified as the silver or as the golden category. dedicated O&M guideline covering few building types is in place, but not mandatory.

Next steps

- Early, Moderate, Advanced: Because certifications for operational performance excellence are not very common in any of the countries, they should start as soon as possible with steps 1 and 2, which are crucial for the development and ratification of suitable instruments.

4.3.3.2 Benchmarking

Definition of activity

By tracking performance and comparing that performance to other buildings (which provide the benchmark), sustainability managers can make educated investment decisions to improve the overall performance of the building operations. Benchmarking can also support energy disclosure, certification, and building passport goals.

Describing sub-roadmap

1. Initiate a national preparatory study to specify the required segmentation (definition of clusters for building or usage zone types, ages, or climate zones) and the required quality of data (e.g. specific energy consumption/demand) separate per energy carrier and consumer (e.g. distinguished for heating, cooling, illumination). Identify available data source on energy demand and consumption and give suggestions to fill data gaps.
2. Acquire the missing data identified at step 1. Likely that requires setting up long-term monitoring. Alternatively, an internet platform could be set up to collect consumption data voluntarily provided by users. As an incentive to provide personal data, the platform should indicate the benchmark consumption.
3. Publish the benchmark and implement in the existing or new tools and instruments (e.g., energy passports or operational certificates).
4. Regularly update the benchmark to consider the technological developments, extend where necessary, and eliminate identified issues.

Describing the status quo of tier groups

- Early Development: No benchmarking activities in place.
- Moderate Development: No official benchmarking actions or policies took place—only initiatives by projects such as preparing building typologies that can be used as benchmarking.
- Advanced Development: Benchmarking for several typologies of buildings. The energy and water data, along with general building characteristics, are used for benchmarking to calculate the annual energy and water use intensities (EUIs and WUIs) per gross conditioned floor area (all), per guest-night (hotels), per student (schools) and per footfall (malls).

Next steps

- Early: Initiate a national preparatory study to identify available data sources on energy demand and consumption of buildings. Then start acquiring the previously identified missing data.
- Moderate: Start with the collection of missing data that is required for a solid national benchmark on the energy performance of buildings. Afterward, publish and advertise the benchmark as soon as possible. Furthermore, identify options to include the benchmark into existing or new tools and instruments.
- Advanced: Update the existing benchmark regularly and identify further options to include the benchmark into existing or new tools and instruments.

4.3.3.3 Information campaigns

Definition of activity

Information campaigns on the relevance of user behaviour and correct system parameter settings are simple options to leverage the mostly no- or low-cost- potentials of building operation—for example, the enormous impact of temperature setpoint on the cooling demand (a change of setpoint from 24 °C to 26 °C leads to 60% reduction of the cooling demand⁵). Private consumers can be reached by such incentives.

Describing sub-roadmap

1. Initiate an analysis of gaps and potentials to identify the most promising topics for information campaigns. Special focus could be set on change of behaviour of private users as that is not easily addressable by other instruments; specific awareness campaigns need to be developed (see Chapter 5)
2. Identify the most suitable media for launching the campaigns.
3. Launch the most promising campaigns.
4. Review the successes by sample surveys and repeat, adapt, or add further campaign according to the feedback received.

Describing the status quo of tier groups

- Early Development: Some campaigns are available to educate users about the energy efficiency.
- Moderate Development: Campaigns and initiatives to reduce the daily electricity consumption. The campaign includes launching of print, outdoor, online, and TV ads informing citizens about energy shortage, identifying efficient energy consumption behaviours, and suggesting methods of lowering daily consumption.
- Advanced Development: Continuous awareness campaigns to change the consumption culture. Each campaign would stresses on one topic, such as that setting the mentioned temperature would save up to 5% of the AC consumption. Also, replacing old ACs with ones with higher efficiency ratings would save up to 25% cooling consumption. Other campaign includes guiding points for using fans, cleaning AC filters, shading elements, stripping and caulking around doors and windows, and using smart thermostats for ACs.

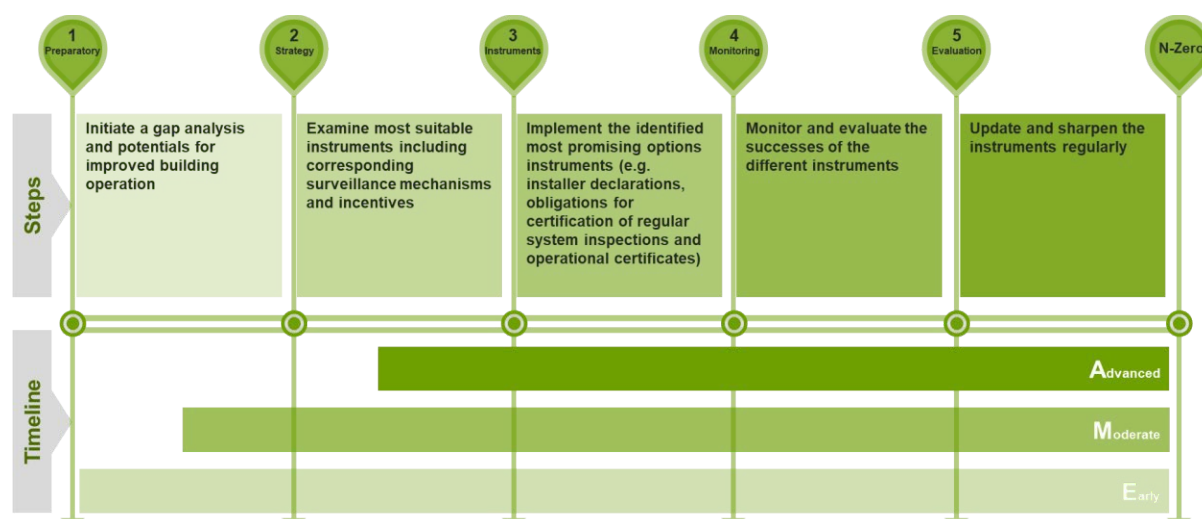
Next steps

- Early: Analyse gaps and potentials to identify the most promising topics for information campaigns, specifically with a focus on change of behaviour. Afterwards launch the most promising campaigns.
- Moderate, Advanced: Review the successes of the existing campaigns repeat and adapt or add further campaigns according to evaluation results.

4.3.3.4 Sub-conclusion

Figure 24 shows the main (aggregated) steps to decarbonise the policy for Activity 4. The bottom half of the figure illustrates the mapping of the three different development phases and the upper half shows the recommended steps.

⁵ For a typical existing residential building in Tunis. Derived from thermal building simulation.



Key message: Transparency, management guidelines, and increasing the efficiency a crucial elements of a successful building operation

Figure 24. Roadmap for Activity 4 – building operations, policy.

4.3.4 Technology for sustainable building operations

The energy use and emissions from buildings are influenced by the quality of building operations. Specific targets and timelines for the sustainable building operation technologies are outlined in the following sections.

4.3.4.1 Soft solutions: Strategies and tools

Tools

Definition of activity: Operations and maintenance (O&M manuals and checklists can support timely and active maintenance of the building with the schedules of specific periodic maintenance actions (e.g. cleaning or replacement of air intake filters). O&M manuals should increasingly be provided at the handover of a system after a retrofit or new installation and be actively used by building managers or operators. Active fault detection is a digital method for identifying maintenance needs and can increasingly be included in system installations and in building management systems. Furthermore, the provision of internet platforms to provide benchmarks and materials like links to related standards and calculation software are helpful tools.

Energy management systems

Definition of activity: Energy management systems enable monitoring of energy consumption of systems, components, or the building as a whole to identify anomalies and understand energy consumption trends. A network of digital energy meters, sensors, or a simple smart meter can form the basis of an energy management system. The interaction between the different technical systems especially at more complex non-residential building typically has high savings potential. Energy management systems of buildings are part of the ISO 50001 processes.

Describing sub-roadmap

1. For all new large public buildings, energy management systems and a documented maintenance system are put in place as those buildings have a role model function.

2. For all new large (size to be specified: e.g. >1,000 m²) buildings and all existing large public buildings, energy management systems and a documented maintenance system are put in place.
3. For all existing large buildings, energy management systems and a documented maintenance system are put in place. All large public buildings have energy management and maintenance systems in place. For all other buildings, operators' information campaigns on the importance of regular maintenance and system parameter adjustment and behavioural saving potentials are initiated.
4. All large buildings have energy management and maintenance systems in place. Everyone is aware of the importance of regular maintenance and system parameter adjustment as well as on behavioural saving potentials.

Describing the status quo of tier groups

- Early Development: No maintenance tools and energy management systems are in place.
- Moderate Development: No maintenance and operation manuals are available. A few suppliers of energy management services (ESCOs) are available in the market, but the implementation/installation rate is low.
- Advanced Development: The Green Building guidelines and certification include guidance for the operation and maintenance of mechanical systems including HVAC systems, ventilation systems and water systems, and central control and monitoring systems. It is a requirement to present the O&M logbook for the application of the certification. The implementation of the energy management system (ISO 50001).

Next steps

- Early, Moderate: Implement energy management systems and documented maintenance systems for all new large public buildings (as a role model). After successful implementation, roll out for all large new large buildings.
- Advanced: Because all large public and all large new buildings have implemented energy management systems and documented maintenance systems, the next step is the roll out to the existing large buildings. For all other building operators, information campaigns on the importance of regular maintenance and system parameter adjustments as well as on behavioural saving potentials should be initiated.

4.3.4.2 Technical equipment

Building management systems

Definition of activity: Building management systems can range from full-scale building software to simple controls that manage individual technologies in a building. Increasingly digital tools are connecting multiple systems in a building with learning and fault detection to improve the overall management of the building system controls. Control systems can range from fully centralised systems to simpler systems such as programmable thermostats. Sensors and controls are increasingly starting to incorporate machine learning to understand occupant preferences and optimise system settings based on internal and external conditions.

Sensors for monitoring

Definition of activity: Sensors for monitoring are fundamental to smart maintenance, audit, energy management, and building management.

Auditing equipment

Definition of activity: Building sustainability audits provide an opportunity to systematically check the optimisation of system configurations and to identify priority retrofit measures. Audit tools (e.g. meters and thermal cameras) can reduce the cost to conduct an audit and improve the rate of annual building audits.

Describing sub-roadmap

1. Large new public buildings are equipped with adequate sensors and central building management systems that make it possible to monitor the key consumers like AC, lighting, heating, and ventilation, and automatically control the systems according to the existing demand. Auditing of those buildings is performed with appropriate tools.
2. Large new buildings and large existing public buildings are equipped with adequate sensors and central building management systems.
3. All large buildings are equipped with adequate sensors and central building management systems.
4. All buildings are equipped with adequate sensors and building management systems.

Describing the status quo of tier groups

- Early Development: The application building management systems, sensors, and controls as well as the use of auditing tools is not common.
- Moderate Development: For building management systems and sensors, suppliers are available in the market, but the implementation/installation rate is still low. The application of sensors is popular with the energy efficiency lighting systems. No audits are available.
- Advanced Development: The Green Building Regulations and Specifications states that all new heating, cooling, and ventilation systems should be adding controls that assure energy efficiency in accordance with ASHRAE 90.1-2007, Section 6.4.3. or equivalent. This confirms the application of the technology related to building management systems. Based on the actions of national distributors, sensors and controls are applied to the HVAC systems helping to reduce the energy consumption while not decreasing the efficiency of the system operation.

Next steps

- Early, Moderate: As an introductory step, at least large new public buildings should be equipped with adequate sensors and central building management systems. After a successful implementation that should be rolled out for all large new buildings.
- Advanced: Presuming that all new building systems are equipped with adequate sensors and central building management systems, extend that requirement to the larger existing buildings.

4.3.4.3 Sub-conclusion

Figure 25 shows the main (aggregated) steps to decarbonise the technology for Activity 4. The bottom half of the figure illustrates the mapping of the three development phases and the upper half shows the recommended steps.

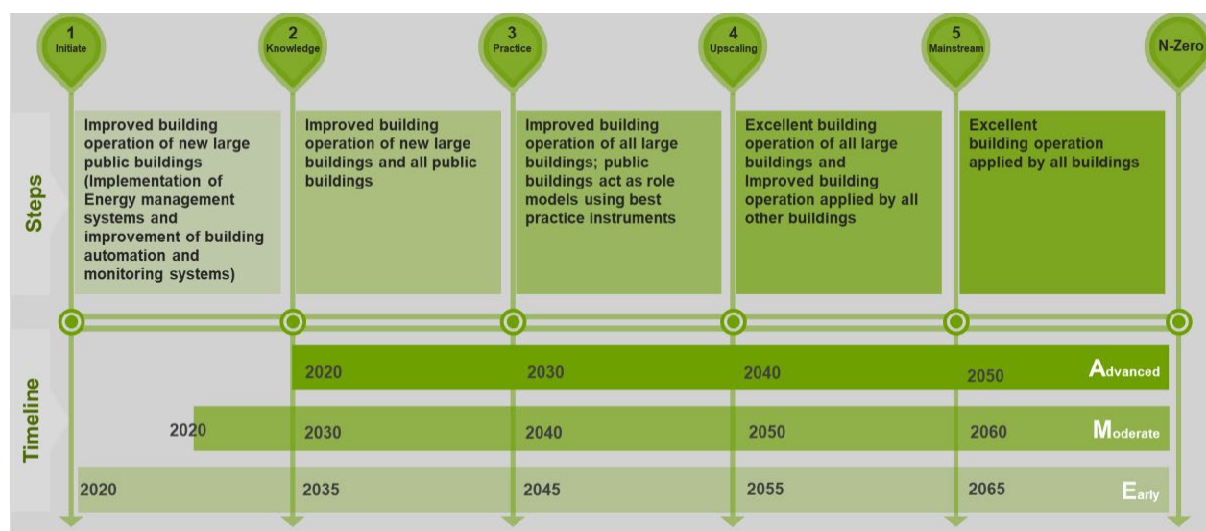


Figure 25. Roadmap for Activity 4 – building operations, technology

4.3.5 Best practices and resources for building operations

Policy/Planning: Smart readiness Indicator for building systems, EU

The European Union (EU) has developed a smart readiness indicator (SRI) that should fill the existing regulatory gap for improved operational performance of building systems, their grid flexibility, and user-friendliness. By ensuring technological innovation in the construction sector gets support, the SRI creates an incentive for the integration of cutting-edge smart technologies in buildings, leading to increased energy efficiency, carbon emission savings, and improved comfort and convenience for building occupants.



1 Readiness to
adapt in response
to the needs of the
occupant



2 Readiness to
facilitate main-
tenance and
efficient operation



3 Readiness to
adapt in response
to the situation of
the energy grid

Source of SRI picture: European Commission, Directorate-General for Energy, Verbeke, S., Aerts, D., Reynders, G., et al., Final report on the technical support to the development of a smart readiness indicator for buildings : final report, Publications Office, 2020, <https://data.europa.eu/doi/10.2833/41100>

Technology/Implementation: Building management system used in an energy efficient retrofitting of a hospital



Source: (MED-ENEC, 2010)

The Centre Hospitalier du Nord, a private hospital in Lebanon, conducted an energy audit, which resulted in recommendations such as improved maintenance of AC equipment, energy efficient lighting, thermal insulation of the roof, and demand management system (peak shaving, monitoring, and control). After implementing these measures, the hospital saves 20% of its overall energy consumption, resulting in yearly cost savings of EUR 55,000 and yearly CO₂ savings of 410 tonnes.

A simple but effective BMS can lead to relevant energy savings, as shown in the example of the Lebanese pilot project of the EuropeAid financed project MED_ENEC (2006-2009). There is not always the need for super complex systems, which only a limited number of people know how to use.

Recommended links/sources

1. LEED Certificate on Operations and maintenance: <https://www.usgbc.org/guide/om>
2. Al Sa'fat – Dubai Green Building System: <https://www.dm.gov.ae/municipality-business/al-safat-dubai-green-building-system/>
3. US Energy Star Checklist for building audits: https://www.energystar.gov/buildings/save_energy_commercial_buildings/ways_save/checklists
4. Tools for the evaluation of complex AC-And ventilation systems (German) https://www.bfee-online.de/BfEE/DE/Service/Onlinetool/einstiegsseite_node.html
5. EU-Energy Performance of Building Directive (Articles 8, 14 and 15): <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L0844&from=EN>
6. EU-Smart Readiness Indicator for Buildings <https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/smart->

4.4 Activity 5: Systems (HVAC and lighting)

Energy-using systems such as lighting, HVAC appliances, and equipment, which commonly have a shorter lifetime than the buildings, offer significant opportunity to reduce emissions in new and existing buildings. Low-emission and efficient systems can also support roadmap goals on clean cooking and lighting to improve the quality of life for building occupants. The following lists three key actions for each development phase:

4.4.1 Key actions for sustainable systems

Key actions for sustainable systems in early starter countries include:

- Initiate research on the local and international status quo regarding the current efficiencies of the different technical building systems within the stock of the country.
- Define minimum suitable and regionally harmonised MEPS for the relevant technical building systems. Implement corresponding regulations including an effective enforcement system for new technical systems.
- Set up independent technical expert groups to define suitable performance requirements for labelling schemes for the relevant technical building systems.

Key actions for sustainable systems in moderate countries include:

- Extend the existing MEPS regulations on all relevant new technical systems. In a next Step
- Broaden the adapted MEPS requirements of new systems also to existing technical systems.
- Set up labelling regulations.

Key actions for sustainable systems in advanced countries include:

- Reshape the existing MEPS and labelling requirements and extend the existing regulations on all relevant technical systems.
- Evaluate short-, mid- and long-term results and successes of the supported research and development activities. Sharpen and extend existing research and development initiatives accordingly.
- Evaluate and adjust the existing green procurement activities.

4.4.2 Stakeholders for sustainable systems

The key stakeholders for sustainable systems include those that can influence technologies and those that can deliver the results of low-emission, efficient, and resilient buildings using sustainable systems. Additional stakeholders include those that can support the process through research, funding, and training. All these stakeholders are essential to delivering on roadmap targets. Table 5 shows the stakeholders; the darker the colour of the cell, the more relevant the stakeholder is. The key stakeholders are marked in bold.

Table 5. Stakeholders for sustainable systems.

Stakeholders	
National government	Sustainable service providers
Subnational government	Civil society
Implementing and enforcement agencies/actors	Sustainable product/material providers
Building authorities and housing associations	Researchers
Engineers, Installers and Architects	Financial institutions
Property developers	Training and capacity institutions/providers
Utility companies and municipal service authorities	Business associations

4.4.3 Policy for sustainable systems

Sustainable systems policy can support emissions, efficiency, and resiliency goals for buildings by enabling market transformation that increases the availability of sustainable products. Within the targets for sustainable systems, the following sub-activities offer more details.

4.4.3.1 Minimum performance standards

Definition of activity

In many countries, lighting, appliance, and equipment products commonly have standards. These standards need to be expanded to all countries and strengthened for higher performance requirements. Testing protocols and enforcement of MEPS are essential for the standards to work effectively, and harmonisation of protocols or MEPS across regions may facilitate this. MEPS should also be in terms of the most adequate performance metric—for example, seasonal energy efficiency ratio (SEER) is a more appropriate metric than the energy efficiency ratio (EER)⁶ as it is more reflective of the appliance's actual consumption over the cooling season. Minimum performance standards should also include limits regarding global warming potential (GWP) of refrigerants and emissions of indoor air pollutants.

Describing sub-roadmap

1. Research: Evaluate the local and international status quo (determine the current efficiencies of the different technical building systems) including related standards.
2. Set up independent technical expert groups to define minimum suitable and regionally harmonised MEPS for the relevant technical building systems. Those should be aligned with the climate targets and considering the local status quo.
3. Create and implement corresponding regulations including an effective enforcement system for new technical systems. That includes the setup of suitable testing labs for imported and locally manufactured products. This step should be accompanied by capacity building activities targeting municipal responsible staff, engineers, and building project developers.
4. Create and ratify corresponding regulations including an effective enforcement system for MEPS of existing technical systems.

⁶ Or the Coefficient of Performance (COP), which is a similar measure but expressed in different units. As there is no international harmonisation regarding names and Global ABC et al. (2020b), values of different countries cannot easily be compared or judged.

5. Periodically monitor and, if necessary, reshape the requirements and the enforcement (e.g. 4-year cycle).

Describing the status quo of tier groups

- Early Development: No physical application of minimum performance standards, but one of the NEEAP (2013-2016) targets is to apply energy labels for refrigerators, lamps, ACs, and fans (Energy Sector of League of Arab States 2012).
- Moderate Development: The implementation of mandatory standards for some electrical products. For example, energy labels are defined for all ACs but not for centralised systems. Values for EER and SEER are included, but the consideration of GWPs is not covered (ISO 13253/2017 Developmentian Organization for Standards).
- Advanced Development: Energy Efficiency Standardization and Labelling programme is available. The programme defines the minimum energy efficiency standards and labels for major power and water end-use applications. Regular updates and reviews ensure the relevance of the programme as further applications, in addition to revision of the current set minimum energy efficiency standards and labels.

Next Steps (until 2030)

- Early: Initiate research on the local and international status quo on the current efficiencies of the different technical building systems. Based on that, define minimum suitable and regionally harmonised MEPS for the relevant technical building systems. Implement corresponding regulations including an effective enforcement system for new technical systems.
- Moderate: Extend the existing regulations on all relevant new technical systems. In a next step, broaden the adapted requirements to existing technical systems.
- Advanced: Periodically monitor and, if necessary, reshape the existing requirements (e.g. for lighting). Extend the existing regulations on all relevant technical systems including ventilation units and heaters (domestic hot water system and heating).

4.4.3.2 Labels

Definition of activity

Product labels on systems and appliances can provide information on the performance of the products including their embodied carbon and their lifecycle energy and carbon performance. This kind of information enables consumers to make choices on a lifecycle basis, but also facilitates the implementation of incentives, MEPS, and phaseout programmes.

Describing sub-roadmap

1. Research: Same as presented in minimum performance standards sub-activity.
2. Set up independent technical expert groups to define suitable performance requirements for labelling schemes for the relevant technical building systems.
3. Create and implement corresponding regulations including an effective enforcement system for the labelling of new technical systems. That includes the setup of suitable testing labs for imported and locally manufactured products.

4. Set up an effective information system (e.g. providing web-based information platforms about best performing product lists, documentation of successful lighthouse project, etc.). Organise exchange platforms and trainings for the key decision makers (installers, architects, and investors).
5. Periodically update the labelling requirements due to technological developments. Optimise the information system due to experiences.

Describing the status quo of tier groups

- Early Development: No labels are available.
- Moderate Development: Improving energy efficiency of some of the products, such as the lighting & building appliances. This is envisaged to be achieved through the combination of regulatory tools such as minimum energy performance standards (MEPS and information labels, enhanced public awareness, capacity building, and attractive financing mechanisms. The project will strengthen the regulatory and institutional framework, develop monitoring and enforcement mechanisms, and provide training to public authorities and other relevant stakeholders. It will explore and test different financial incentives complemented by extensive public outreach campaigns (UNDP 2019).
- Advanced Development: Same as presented in minimum performance standards sub-activity.

Next steps

- Early: Initiate research on the local and international status quo on the current efficiencies of the different technical building systems. Then set up independent technical expert groups to define suitable performance requirements for labelling schemes for the relevant technical building systems. Create and implement corresponding regulations including an effective enforcement system.
- Moderate: Presuming that the necessary background information is available and suitable performance requirements for labelling schemes have been developed by independent technical expert groups, the corresponding regulations including an effective enforcement system is to be achieved.
- Advanced: Periodically monitor and if necessary, reshape the existing requirements for labelling (e.g. for lighting) Extend the existing labelling regulations on all relevant technical systems including ventilation units and heaters (domestic hot water system and heating).

4.4.3.3 Research and development

Definition of activity

Increasing research funding can enable the invention of new products and services while increasing the ability to get improved technologies to the market cost-effectively. Although the main research activities take place in the developed leading industry countries, countries with local manufacturers and topic-specific research centres can also contribute.

Describing sub-roadmap

1. Preparatory steps: Identify the boundary conditions, such as availability of funding and existence of research centres or local manufacturers. Based on that, decide in which fields a research funding should be set up.

2. Conception and instruments: If due the preparatory examinations research funding makes sense, an application platform should be set up. Additionally, or alternatively, innovation prizes or other supporting alternatives can be set up. The research topics and aims to be supported by specific independent expert groups and should consider the international state of research in correlation to the country's potential. This step should be accompanied by capacity building activities targeting municipal responsible staff, engineers, and building project developers.
3. Documentation, and reporting: The result of the funded research needs to be documented and published to contribute to the international research for the evaluation of the programmes.
4. Evaluation and adjustment: Evaluation on the short, - mid- and long-term successes of the research and development (R&D) activities. Based on that, the topics and activities should be adjusted.

Describing the status quo of tier groups

- Early Development: No research funding for the invention of new products and services are available.
- Moderate Development: Some small initiatives are available. Policies related to energy efficiency are fostering such a kind of research funding, but it works slowly. Other funding opportunities for research through foreign organisations are available.
- Advanced Development: Research and Development (R&D) Policy and Research and Development Council are established to strengthen the performance and effectiveness of the science and technology (S&T) sector and its efforts to achieve a knowledge-based economy”.

Next steps

- Early: Identify the boundary conditions, such as availability of funding and existence of research centres or local manufacturers. Based on that, decide in which fields a research funding should be set up.
- Moderate: Support and complement existing R&D initiatives. If possible and promising, extend the existing funding programmes. Make sure the results are documented and published.
- Advanced: Evaluate the short-, mid-, and long-term results and successes of the supported R&D activities. Sharpen and extend existing R&D initiatives accordingly (e.g. more focus on buildings sector).

4.4.3.4 Procurement

Definition of activity

Public and private entities can purchase sustainable products and services to support the effort to phase out the use of unsustainable products and services. This effort should be done by public and private entities and can include bulk procurement or minimum performance specifications for procurement rules. The target in the roadmap refers to increasing shares of green procurement, which is procurement based on minimum specifications such as minimum energy efficiency or other environmental standards.

Describing sub-roadmap

1. Preparation: Evaluate the local and international status quo (determine the potentials of the different technical building systems, e.g. avoiding fluorinated refrigerants).
2. Strategy and conception: Develop suitable strategies, which may include informational actions, subsidies, or specific regulations. Examine the expected impacts of the different options. Decide the most suitable in terms of impact on the sustainability in relation to the effort for the involved stakeholders. The strategy must promote the use of locally and regionally available materials.
3. Activate the strategies as planned. In parallel, a suitable monitoring system should be created for a later evaluation and adjustment of the activities.
4. Evaluate the successes and efforts of the activities compared to the conception. Based on that, the activities should be adjusted.

Describing the status quo of tier groups

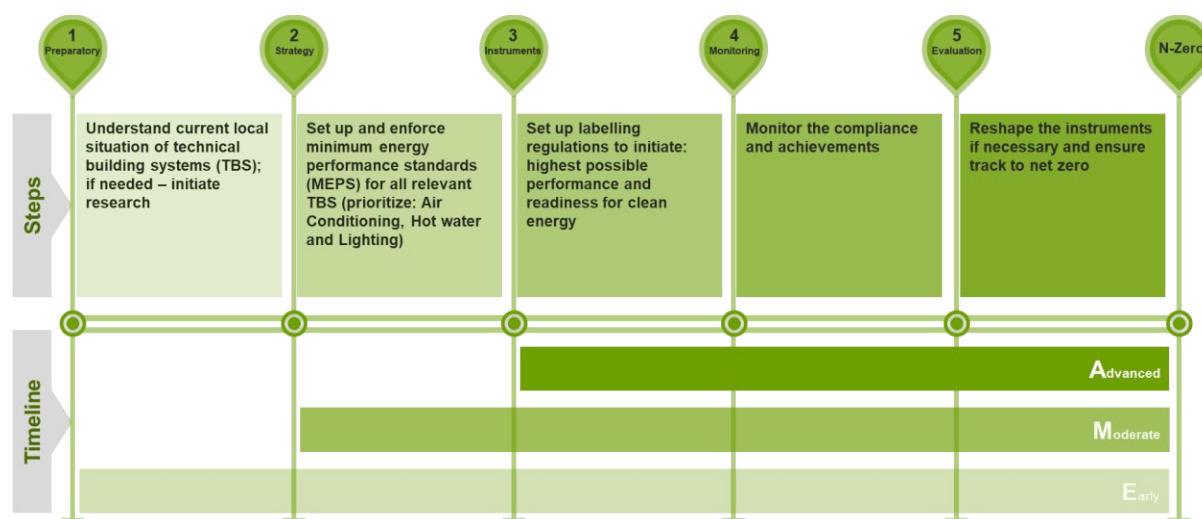
- Early Development: No procurement activities for phasing out using unsustainable materials are happening.
- Moderate Development: Some initiatives are available in the field of procurement. Initiating the development of a list of standards and guidelines that would support the green public procurement process, where the government would obligate other agencies to follow. An Environmental Sustainability Standards Manual is developed, which aims to include standards for sustainable development into development plans. It also aims to achieve doubling of the percentage of green public investments.
- Advanced Development: The guidelines for green buildings includes a mandatory section on the procurement of sustainable materials such as certified timber, recycled aggregates, and recycled steel.

Next steps

- Early: Initiate an evaluation of the local and international status quo on green procurement. Based on that, develop suitable strategies, which may include informational actions, subsidies, or specific regulations. The strategy must promote the use of locally and regionally available materials.
- Moderate, Advanced: Evaluate the successes and efforts of the activities compared to the conception. Based on that, adjust the activities.

4.4.3.5 Sub-conclusion

Figure 26 shows the main (aggregated) steps to decarbonise the policy for Activity 5. The bottom half of the figure illustrates the mapping of the three development phases and the upper half shows the recommended steps.



Key message: MEPS and labelling to promote highly efficient technical building systems.

Figure 26. Roadmap for Activity 5 – systems, policy.

4.4.4 Technology for sustainable systems

The energy use and emissions from buildings are influenced by the systems used in the buildings. Specific sub-activities for the sustainable system technologies are outlined in the following sections.

4.4.4.1 Mechanical cooling systems

Definition of activity

While cooling is the fastest growing end use in buildings globally, cooling technology can enable more efficient delivery of thermal comfort through improved peak demand efficiency (EER) and seasonal efficiency (SEER). Adoption of hybrid cooling methods, such as evaporative cooling, ventilative cooling, and other free cooling that uses low nighttime air, ground, or water temperatures can support the increased overall efficiency. Overall performance of the space cooling system is based on the efficiency of the cooling equipment and the thermal distribution system, such as ducts or pipes, to deliver the cooling within the building. Cooling system sustainability can also be improved using low GWP refrigerants.

Describing sub-roadmap

1. All new systems (in new and existing buildings) fulfil the minimum performance appliance and system requirements (e.g. EU Ecodesign⁷). Central systems are prepared to be enabled for a 100% renewable energy supply. Includes at least spaces for storage (thermal or electrical) and interfaces for grid signals or signals from an onsite PV system.
2. Penetration of at least 50% of the stock with minimum efficient renewable-ready technology. All new systems fulfil good performance appliance and system requirements (far above the minimum), are prepared for renewable energy supply, and fulfil minimum sustainability requirements (e.g. no fluorinated refrigerants).
3. Penetration of at least 50% of the stock with good performance appliance and system requirements (far above the minimum), are prepared for renewable energy supply, and fulfil minimum sustainability requirements. All new systems fulfil highest feasible

⁷ Example: Minimum Efficiency for small split units (< 6 kW): SEER ≥ 4,14 with refrigerant GWP ≤ 150 and SCOP ≥ 4,6 with refrigerant GWP > 150 (derived from laboratory testing for a predefined average cooling season)

performance appliance and system requirements, 100% renewable energy supply, and fulfil feasible sustainability requirements.

4. All heating systems are sustainable, efficient, and 100% served by renewable energy (solar electric or thermal).

Describing the status quo of tier groups

- Early Development: No enhancement of the mechanical cooling system in terms of energy efficiency is available.
- Moderate Development has a code of practice for HVAC and refrigeration. The code is mandatory but not enforced for application except for large projects such as malls, hospitals, and large public buildings. The suppliers and products of energy efficiency systems and appliances are available but rarely implemented.
- Advanced Development: Values for COP for window ACs and non-ducted split AC units were defined and published. Below is an example (Dubey and Krarti 2017) shows the different ranges of COPs for small ACs:

Table 6. Efficiency ranges of ACs

Star rating	Window Air Conditioners [W_{th}/W_{el}]	Non-Ducted Split AC Units [W_{th}/W_{el}]
5	COP > 2.49	COP > 2.64
4	2.49 < COP < 2.35	2.6 < COP < 2.4
3	2.35 < COP < 2.2	2.4 < COP < 2.26
2	2.2 < COP < 2	2.26 < COP < 2.1
1	2 < COP < 1.9	2.1 < COP < 2

Next steps

- Early, Moderate: As a first step, all new systems should fulfil minimum performance appliance and system requirements and should be prepared to be enabled for a renewable energy supply,⁸ After 5-10 years, a penetration of at least 50% of the stock with minimum efficient renewable-ready technology should be reached. At that time, all new systems should fulfil good performance appliance and system requirements (far above the minimum), be prepared for renewable energy supply, and fulfil minimum sustainability requirements (e.g. no fluorinated refrigerants).
- Advanced: A penetration of at least 50% of the stock with minimum efficient renewable-ready technology should be achieved for all types of AC systems. All new systems fulfil good performance appliance and system requirements (far above the minimum), are prepared for renewable energy supply, and fulfil minimum sustainability requirements (e.g. no fluorinated refrigerants). After 5-10 years, a penetration of at least 50% of the stock have good performance appliance and system requirements (far above the minimum), and those systems are prepared for renewable energy supply and fulfil minimum sustainability requirements. All new systems should fulfil highest feasible

⁸ If requirements are already in place but not effective, the enforcement should be improved.

performance appliance and system requirements, 100% renewable energy supply, and fulfil feasible sustainability requirements.

4.4.4.2 Space heating systems

Definition of activity

Where applicable heating technology can enable more efficient delivery of space comfort through improved system efficiency. Heating systems also offer an opportunity for decarbonisation in the transition from fossil fuel heating systems to electricity or renewable energy heating systems. Overall performance of the space heating system is based on the efficiency of the heat generator and the thermal storage and distribution system, such as water tanks, ducts, pipes, fans and pumps, and the delivery systems (with or without a fan). Key technologies to achieve these reductions are heat pumps, modern biomass stoves and boilers, the phasing out of traditional biomass, and the use of waste heat or cogeneration.

Describing sub-roadmap for countries with a significant heating demand

1. All new systems (in new and existing buildings) fulfil defined minimum performance appliance and system requirements (e.g. aligned to EU Ecodesign⁹) and are prepared to be enabled for a 100% renewable energy supply (e.g. smart grid-ready heat pumps). Reversible split units should only be allowed if the heating demand is low (e.g. < 5 kWh/m²a). Direct electricity heating should only be allowed if a negligible heating demand.
2. Penetration of at least 50% of the stock with minimum efficient renewable-ready technology. All new systems fulfil good performance appliance and system requirements (far above the minimum), are prepared for renewable energy supply, and fulfil minimum sustainability requirements (e.g. no fluorinated refrigerants).
3. Penetration of at least 50% of the stock with good performance appliance and system requirements (far above the minimum), are prepared for renewable energy supply, and fulfil minimum sustainability requirements. All new systems fulfil highest feasible performance appliance and system requirements, 100% renewable energy supply, include energy storage systems, and fulfil feasible sustainability requirements.
4. All heating systems are sustainable, efficient, and 100% served by renewable energy. As solar energy may not be sufficient in most countries, other renewable energy sources such as renewable electricity by wind power (including suitable storage) or biomass will be necessary.

Describing the status quo of tier groups

- Early Development: No application of efficient space heating systems is available.
- Moderate Development: No application of this sub-activity takes place.
- Advanced Development: The energy efficiency standards labelling (EESL), which defines the parameters of the HVAC appliances (intertek 2015), includes space heating efficiency standards along with cooking (stoves, etc.).

⁹ Example: Minimum Efficiency for reversible split unit in heat mode (since January 2014): SCOP $\geq 3,42$ with refrigerant GWP ≤ 150 and SCOP $\geq 3,8$ with refrigerant GWP > 150 (derived from laboratory testing for a predefined average heating season)

Next steps

- Early, Moderate, Advanced: In first step, all new heating systems should fulfil minimum performance appliance and system requirements and should be prepared to be enabled for a renewable energy supply. After 5-10 years, a penetration of at least 50% of the stock with minimum efficient renewable ready technology should be reached. At that time, all new systems should fulfil good performance appliance and system requirements (far above the minimum), be prepared for renewable energy supply, and fulfil minimum sustainability requirements (e.g. no fluorinated refrigerants).

4.4.4.3 Ventilation

Definition of activity

To ensure good indoor air quality and minimum energy demand, controlled ventilation is essential. The three primary ventilation types include mechanical, natural, and hybrid-ventilation. The most common natural ventilation is via a manual opening of windows. As it is practically impossible to always achieve an optimal balance between comfort and energy efficiency with this ventilation, additional alternative solutions should be taken into consideration. Those could be controlled¹⁰ window or façade vents, which can react upon outside and inside climate. One other option to increase the ventilation and energy efficiency, buildings can be a hybrid ventilation, which uses natural ventilation when feasible and mechanical ventilation when natural ventilation is not effective or efficient. For highly efficient mechanical ventilation systems, a demand control and good fan efficiency is crucial. To further improve the efficiency, the system could include energy recovery ventilation technology to enable air exchange with minimal heat and humidity transfer. Mechanical ventilation systems with a good energy recovery reach recovery rate of 80-90%. A regular inspection not only for filter exchange is crucial to maintain the efficiency. The most economical and efficient measure at ventilation can usually be achieved at large mechanical ventilation systems.

Describing sub-roadmap

1. The components of all new ventilation systems fulfil the defined minimum air quality and performance requirements all systems above a certain size threshold¹¹ and fulfil the defined minimum performance systems requirements (e.g. for the specific fan power, demand control and the heat recovery efficiency).
2. Penetration of at least 15% of systems in stock fulfil the minimum air quality and performance for components and systems. All new components and systems need to fulfil improved performance requirements (above the minimum). Start with inspection of large existing systems and raising awareness of private users.
3. Penetration of at least 50% of systems in stock fulfil the minimum air quality and performance for components and systems. At least 15% new components and systems fulfil improved performance requirements (above the minimum). At least 50 % of large existing systems are inspected.

¹⁰ Systems do not need to have an electrical control. An intelligent construction with integration of simple bimetal or springs can be sufficient

¹¹ E.g., 3000 m³/h; Suitable size be determined considering economical aspects (expected cost-benefit for the operator) and relevance for national climate target

4. All systems in stock fulfil the minimum air quality and performance for components and systems. At least 50% new components and systems fulfil improved performance requirements (above the minimum). All large existing systems are inspected.
5. All systems in stock have highest feasible performance and guarantee a sufficient air quality.

Describing the status quo of tier groups

- Early Development: Ventilation measure consideration is not applied.
- Moderate Development: Retrofits are mentioned in the energy efficiency code are only covering limited buildings' typology. No different thresholds or values are mentioned for retrofits, only the same values for new buildings are set as targets.
- Advanced Development: The guidelines for green buildings requires new buildings to ensure indoor air quality meets minimum standards and must comply with Sections 4-7 in ASHRAE 62.1-2013. The guidelines also ask to install CO₂ sensors in densely occupied spaces considering that the CO₂ concentration levels should not exceed 1,000 ppm. It is requiring that the amount of supply air shall be approximately equal to the amount of return and exhaust air. The system shall not be prohibited from producing negative or positive pressure. Air handling units shall deliver filtered and conditioned air within the building. Air handling units shall be American Heating and Refrigeration Institute, or Euro vent certified. Still no criteria are available connecting between the ventilation process and the energy efficiency of the building.

Next steps

- Early, Moderate, Advanced: The components of all new ventilation systems fulfil minimum air quality and performance requirements all systems above a certain size threshold and fulfil the minimum performance systems requirements (e.g. for the specific fan power, demand control and the heat recovery efficiency). After about 5 years, at least 15% of new components and systems should fulfil these requirements. All new components and systems need to fulfil improved performance requirements (above the minimum). Start with inspection of large existing systems and raising awareness of private users.

4.4.4.4 Water heating systems

Definition of activity

Available technologies can enable more sustainable and improved system efficiency. Solar thermal water heaters, efficient heat pumps, or efficient biomass boilers as well as the use of waste heat and cogeneration offer effective solutions for decarbonising water heating.

Describing sub-roadmap

1. All new systems (in new and existing buildings) fulfil the minimum performance appliance and system requirements (e.g. EU Ecodesign) and where feasible feed by min. 50% renewable energy.
2. Penetration of at least 50% of the stock with minimum performance and min. 50% renewable energy. All new systems fulfil improved performance (appliance and system requirements); when feasible, need to be fed by min. 80% renewable energy, fulfil minimum sustainability requirements (e.g. 80% renewable energy), and fulfil minimum sustainability requirements (e.g. no fluorinated refrigerants).

3. Penetration of at least 50% of the stock with higher performance and min. 80% renewable energy and fulfilling feasible sustainability requirements.
4. All water heating systems are sustainable efficient and by close to 100% served by renewable energy (solar- electric or thermal, waste heat or biomass).

Describing the status quo of tier groups

- Early Development: No development is occurring in the field of energy efficiency connected to water heating systems.
- Moderate Development: The enhancement of the use of solar heaters is required. Products are available in the market but due to the high initial investment the penetration rates are not high. The use of biomass boilers, waste heat or cogeneration are not applied widely.
- Advanced Development: Requirements are established for electric storage water heaters for household and similar purposes and intended for heating water below boiling temperature (their rated capacity being not more than 500 L). The products need to meet at least a minimum energy efficiency index of 135%. Categorisation example of water heaters, and energy efficiency rating example of water heaters from UAE, are as follows:

Table 7. Categorisation water heaters (ECAS Development).

Class	Description
1	Unvented electric storage water heaters having a rated capacity not exceeding 30 litres
2	Open-outlet electric storage water heaters having a rated capacity not exceeding 30 litres
3	Horizontal tank type electric storage water heaters having a rated capacity 30 litres up to 500 litres
4	Vertical tank type electric storage water heaters having a rated capacity 30 litres up to 500 litres

Table 8 shows the ranges of energy efficiency indices.

Table 8. Energy efficiency ratings of water heating systems in UAE.

Star Rating	Energy Efficiency Index (EEI) (%) I_e
5	$I_e \leq 70$
4	$70 < I_e \leq 85$
3	$85 < I_e \leq 100$
2	$100 < I_e \leq 115$
1	$100 < I_e \leq 130$

Next steps

- Early, Moderate: Primarily all new systems should fulfil the minimum performance appliance and system requirements and where feasible feed by min. 50 % renewable energy. After 5-10 years, a penetration of at least 50% of the stock with minimum efficient renewable ready technology should be reached. At that time, all new systems should fulfil good performance appliance and system requirements (far above the minimum), be prepared for renewable energy supply, and fulfil minimum sustainability requirements (e.g. no fluorinated refrigerants).

- **Advanced:** Due to existing requirements, a penetration of at least 50% of the stock with minimum performance and min. 50% renewable energy it should be achieved. Furthermore, should all new systems fulfil improved performance (appliance and system requirements); when feasible, need to be fed by min. 80 % renewable energy and fulfil minimum sustainability requirements (e.g. no fluorinated refrigerants.) After 5-10 years, a penetration of at least 50% of the stock with higher performance and min. 80% renewable energy and fulfilling feasible sustainability requirements should be reached.

4.4.4.5 Lighting

Definition of activity

Lighting technology can enable more efficient delivery of visual comfort through improved lumens per watt efficiency (lm/w). Lighting technology developments in more efficient solid-state lighting (SSL) is improving the quality of light, efficiency, maintenance , and reducing costs. Daylight harvesting systems with intelligent controls, sensors, and shading devices can also support the target for increased lumens per watt.

Describing sub-roadmap

1. Ban for sales of inefficient lighting: All new lighting bulbs and systems are very efficient (e.g. LED).
2. Minimum 50% of the stock lighting bulbs and systems are energy efficient (e.g. LED). Where applicable, in new buildings light sensors (presence, motion detector or daylight) are installed.
3. Nearly all of the stock lighting bulbs and systems are energy efficient (e.g. LED). Where applicable, all buildings attendance and light sensors are installed.

Describing the status quo of tier groups

- **Early Development:** No actions are taken in terms of the energy efficiency of lighting.
- **Moderate Development:** Lighting initiative projects with a target to accelerate the growth of the energy efficiency lighting market are available. The project supports in the direction of MEPS, information labels, public awareness, and capacity building. Daylight harvesting systems with intelligent controls, sensors, and shading devices are still not widely applied.
- **Advanced Development:** Established regulation of the lighting standard prevents low quality, unsafe, and less energy efficient lighting fixtures from entering the market. In particular, the sale and manufacture of incandescent lamps and low efficiency CFLs is banned. Following the lighting standards, high efficient bulbs includes: Compact Fluorescent Lamps (CFLs), Light Emitting Diodes (LEDs), halogens.

Next steps

- **Early:** Start with a ban for sales of inefficient lighting. All new lighting bulbs and systems are very efficient (e.g. LED). After 5 years, minimum 50% of the stock lighting bulbs and systems should be energy efficient. Where applicable, in new buildings attendance and light sensors should be installed.
- **Moderate:** Ongoing activities should result in 50% of the stock lighting bulbs and systems being energy efficient (e.g. LED). Where applicable, in new buildings attendance and light sensors should be installed. After 5 years nearly all the stock lighting bulbs and systems

should be energy efficient (e.g. LED). Where applicable in all buildings attendance and light sensors should be installed.

- Advanced: Ongoing activities should result to that nearly all of the stock lighting bulbs and systems are energy efficient (e.g. LED). Where applicable, all buildings attendance and light sensors should be installed.

4.4.4.6 Smart devices

Definition of activity

Ongoing digitalisation of electric appliances is unveiling new opportunities to improve resource efficiency and flexibility and allow consumers to manage their consumption through demand-side response. Appliances such as ACs and other devices should increasingly be equipped with the capacity for smart or connected control.

Describing sub-roadmap

1. All new heating, cooling and ventilation appliances consist of automatic demand controls.
2. 50% of heating, cooling, and ventilation appliances consist of automatic demand controls. All new electrical heating and cooling appliances consist of grid demand response.
3. All applicable heating, cooling, and ventilation appliances consist of automatic demand controls. 50% of the electrical heating and cooling appliances consist of on-grid demand response.
4. All applicable heating, cooling, and ventilation appliances consist of automatic demand controls. All electrical heating and cooling appliances consist of grid demand response.

Describing the status quo of tier groups

- Early Development: No smart devices are widely used.
- Moderate Development: The technology of introducing smart devices to control the resources' consumption from the demand side is available in the market but still limited in the scale of implementation.
- Advanced Development: High presence of the smart device technology.

Next steps

- Early, Moderate: In a first step, all new heating, cooling, and ventilation appliances should consist of automatic demand controls. After 5-10 years, that should have led to 50% of heating, cooling, and ventilation appliances consisting of automatic demand controls. From that time onwards, all new electrical heating and cooling appliances should include on-grid demand response.
- Advanced: Assuming that most of the new heating, cooling, and ventilation appliances consist of automatic demand controls, 50% of HVAC appliances should consist of automatic demand controls. All new electrical heating and cooling appliances should consist of grid demand response. After 5-10 years, all applicable HVAC appliances consist of automatic demand controls and 50% of the electrical heating and cooling appliances should include on-grid demand response.

4.4.4.7 Appliances

Definition of activity

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

Describing sub-roadmap

1. Step 1: All new appliances fulfil the minimum performance requirements. Minimum performance requirements could be set e.g. in line with EU Ecodesign regulation.
2. Step 2: Min 25% of all appliances fulfil the minimum performance requirements. All new appliances fulfil in average higher performance requirements (e.g. a certain efficiency class due to EU labelling directive).
3. Step 3: Min 50% of all appliances fulfil the minimum performance requirements. Min. 25% of appliances fulfil higher performance requirements. Min. 25% of appliances fulfil higher performance requirements.
4. Step 4: Nearly all appliances fulfil the minimum performance requirements. Min 50% of appliances fulfils higher performance requirements. Min 50% of appliances fulfils higher performance requirements.
5. Step 4: Nearly all appliances fulfil higher performance requirements.

Describing the status quo of tier groups

- Early Development: No consideration for energy efficiency is widely applicable.
- Moderate Development: The implementation of mandatory standards for some electrical products is available. Still the inclusion of digitalised appliances, sensors, controls, and further automation is not widely implemented.
- Advanced Development: Energy efficiency standards labelling is implemented. A wide range of electronic appliances are rated and labelled such as Domestic AC, commercial and central air conditioners, washing machines, dryers, refrigerators, freezers, storage water heaters and dishwashers.

Next steps

- Early: Firstly, all new appliances should fulfil minimum performance requirements. After 5 years more than 25% the appliances should fulfil the minimum performance requirements and new appliances fulfil in average higher performance requirements.
- Moderate: As already minimum performance requirements of systems are set the next step is to achieve 25% of the appliances fulfil those requirements. Furthermore, from that time all new appliances shall fulfil in average higher performance requirements. After further 5 years more than 50% of the appliances fulfil minim requirements and 25 already higher requirements.

- **Advanced:** As minimum requirements are already set since a longer time the upcoming aim should be that nearly all existing appliances fulfil the minimum performance requirements and min. 50% of appliances fulfil higher performance requirements. Within the upcoming 10 years nearly all appliances shall then fulfil higher performance requirements, which regularly should be further improved.

4.4.4.8 Energy storage

Definition of activity

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

Describing sub-roadmap

1. Early adopters implement smart grid ready storages.
2. Minimum of 10% of the grid storage potential is activated.
3. Minimum of 25% of the grid storage potential is activated.
4. Minimum of 50% of the grid storage potential is activated.
5. Maximum of the grid storage potential is activated.

Describing the status quo of tier groups

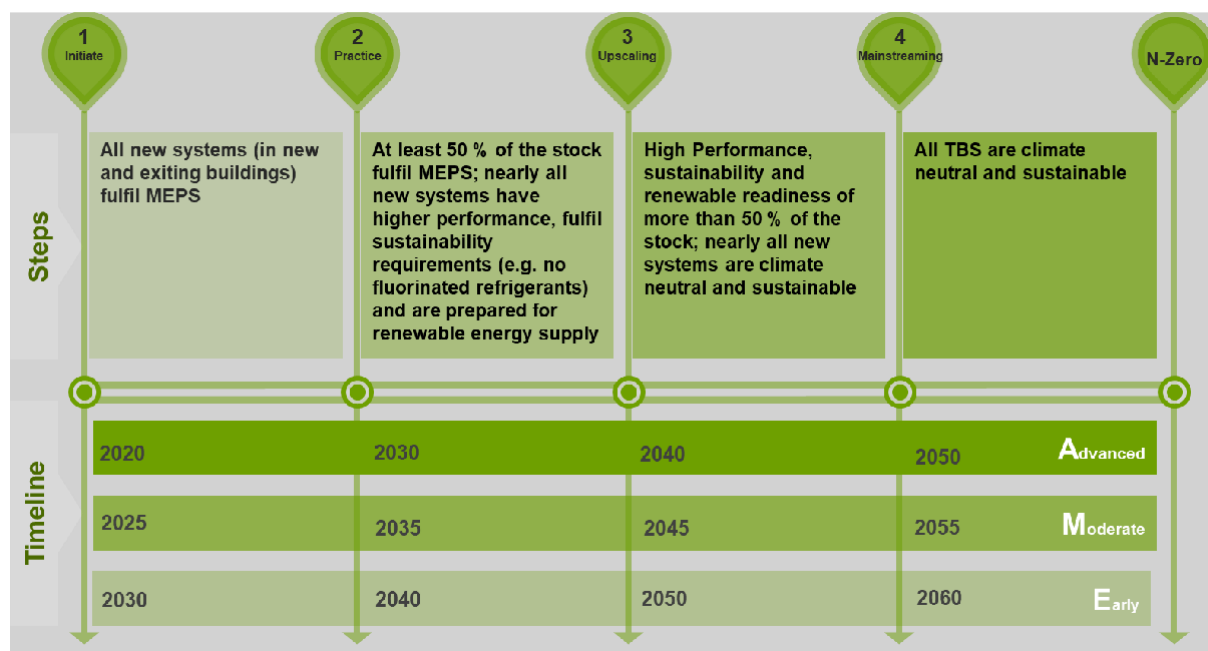
- **Early Development:** The technology of energy storage is not available.
- **Moderate Development:** The application of energy storage is restricted to large projects as the association of thermal energy storage with solar thermal power plant, but still it is not applied on the scale of the buildings sector.
- **Advanced Development:** Thermal storage for district cooling is applied. All new district cooling plants must incorporate a Thermal Energy Storage (TES) facility. TES shall be designed with a capacity of at least 20% of the designed plant capacity.

Next steps

- **Early:** Early adopters should start implement smart grid-ready storage. Within the upcoming decade minimum 10% of the grid storage potential should have been activated.
- **Moderate:** The activities should be accelerated that 10% of the grid storage potential has been activated. Moderate: The activities should be accelerated that 10% of the grid storage potential has been activated. After further 5-10 years 25% of the grid storage potential should be activated.
- **Advanced:** Due to the activities in the recent years the goal of and activation of 25% of the grid storage potential should be able to be achieved shortly. The goal for the next decade should therefore be an activation of min.50%.

4.4.4.9 Sub-conclusion

Figure 27 concludes the main (aggregated) steps to decarbonise the technology for Activity 5. The bottom half of the figure illustrates the mapping of the three development phases and the upper half shows the recommended steps.



Key message: Technical building systems need to have a high efficiency and allow a proper integration of clean energies

Figure 27. Roadmap for Activity 5 – systems, technology.

4.4.5 Best practices and resources for systems

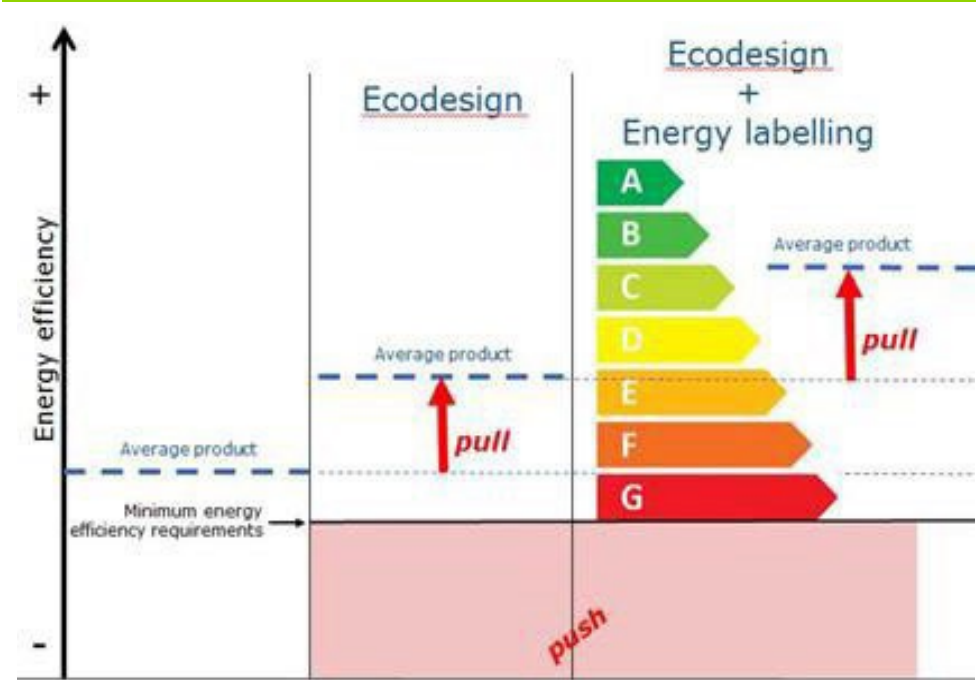
Recommended Links/Sources MEPS and Labelling Regulations

1. https://ec.europa.eu/info/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/energy-label-and-ecodesign/rules-and-requirements_en
2. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=48&action=viewlive

UAE Labelling and MEPS

3. https://members.wto.org/crnattachments/2019/TBT/ARE/19_1431_00_e.pdf

Policy/Planning: MEPS and labelling regulations, Ecodesign Directive, EU



Source: [https://eur-lex.europa.eu/legalcontent/EN/TXT/HTML/?uri=PI_COM:C\(2019\)1796&from=IT](https://eur-lex.europa.eu/legalcontent/EN/TXT/HTML/?uri=PI_COM:C(2019)1796&from=IT)

The EU directive on Ecodesign requirements for individual product groups applies to 31 product groups. It also establishes a consultation forum to consult stakeholders, including representatives from EU countries, industry, and civil society, on the implementation of the directive.

Technology/Implementation: Natural refrigerants to reduce direct emissions

CITY AND BUILDINGS



REFRIGERANTS

- CO₂ Carbon dioxide
- NH₃ Ammonia
- HC Hydrocarbons
- H₂O Water
- AIR Air

USE

- heating
- refrigeration
- cooling

Residential	Office buildings	Hospitals	Universities
CO ₂ NH ₃ HC H ₂ O AIR	CO ₂ NH ₃ HC H ₂ O AIR	CO ₂ NH ₃ HC H ₂ O AIR	CO ₂ NH ₃ HC H ₂ O AIR
Shopping Malls	Data Centres	District heat. and cool.	Airports
CO ₂ NH ₃ HC H ₂ O AIR	CO ₂ NH ₃ HC H ₂ O AIR	CO ₂ NH ₃ HC H ₂ O AIR	CO ₂ NH ₃ HC H ₂ O AIR

Source: Adapted from shecco guide for natural refrigerants training Europe 2017;
Icon credits: Heating (Nikita Golubev), Refrigeration (smashicons) and Air conditioner (Handicon)

Natural refrigerants such as carbon dioxide, ammonia, hydrocarbons, water and air can be used to reduce direct emissions from several building types. The image above is a mapping of the natural refrigerants for different building types. A grey highlight represents that the specific refrigerant is not applicable for the given building type.

4.5 Activity 6: Materials

Construction activity in the buildings sector is generating a major flow of materials, with a large impact on climate change. GHG emissions or energy consumption are linked to every phase of the lifecycle of materials, from extraction or harvesting to manufacture, transport, construction, use and demolition. For instance, steel, bricks, cement, non-certified wood (deforestation issue), or high GWP refrigerants used in systems are some of the major building product emitters of GHG. Key actions for sustainable materials

Key actions to enable increased sustainable materials in early starter countries include:

- Collect data on embodied carbon of buildings and construction materials. Develop a database that can be accessed by all stakeholders and allows comparisons and calculations. Develop guidance on the use of methodologies and standards for making calculations and assessments.
- Promote capacity on low-carbon materials and technologies among professionals involved in the building design and construction process. Provide tools, training, and capacity building. Conduct or commission research into low-carbon materials and approaches. Carry out or commission case studies to convey the benefits of use of low-carbon materials and raise awareness.
- Integrate considerations of embodied carbon in planning and building regulations, require disclosure for all new construction and for large renovation projects, initiate low-carbon materials pilot projects, and provide incentives to property and project developers.

Key actions to enable increased sustainable materials in moderate countries include:

- Provide information and raise awareness. Promote capacity on low-carbon materials and technologies among professionals involved in the building design and construction process. Provide tools, training, and capacity building. Conduct or commission research into low-carbon materials and approaches. Carry out or commission case studies to convey the benefits of use of low-carbon materials and raise awareness.
- Integrate considerations of embodied carbon in planning and building regulations, require disclosure for all new construction and for large renovation projects, initiate low-carbon materials pilot projects, and provide incentives to property and project developers.
- Accelerate energy efficiency and the integration of clean energy in manufacturing. Develop measures to effectively speed up the implementation of energy efficiency and clean energy in industries that manufacture buildings and construction materials. Promote energy management, develop best practice guides, and support the adoption of best available technologies (BATs). Include building material manufacturing industries as part of demand-side management efforts.

Key actions to enable increased sustainable materials in advanced countries include:

- Accelerate energy efficiency and the integration of clean energy in manufacturing. Develop measures to effectively speed up the implementation of energy efficiency and clean energy in industries that manufacture buildings and construction materials. Promote energy management, develop best practice guides, and support the adoption of BATs. Include building material manufacturing industries as part of demand-side management efforts.
- Stimulate markets for low-carbon products and materials. Implement policies that enable improved design and purchasing decisions based on embodied carbon and energy. This could be achieved combining push levers, such as carbon pricing, tax incentives, subsidies, and regulations on production of materials, with pull levers, such as public procurement and regulations on the construction sector. Develop policies that ensure all government buildings invest in low-carbon and efficient materials based on LCAs.
- Support the development of material reuse and recycling processes for products and materials that can reduce the lifecycle embodied energy and emissions and increase the use of repurposed materials in product manufacturing and in buildings and construction projects.

4.5.1 Stakeholders for sustainable materials

In the Arab region, the key stakeholders for sustainable materials include those that can influence materials and those that can deliver the results of low-emissions, efficient, and

resilient buildings using sustainable materials. Additional stakeholders include those that can support the process through research, funding, and training. All these stakeholders are essential to delivering on roadmap targets. Table 9 shows the stakeholders; the darker the colour of the cell, the more relevant the stakeholder is. The key stakeholders are marked in bold.

Table 9. Stakeholders for sustainable materials.

Stakeholders	
National government	Sustainable service providers
Subnational government	Civil society
Implementing and enforcement agencies/actors	Sustainable product/material providers
Building authorities and housing associations	Researchers
Architects and engineers	Financial institutions
Property developers	Training and capacity institutions/providers
Utility companies and municipal service authorities	Local community groups and business associations

4.5.2 Policy for sustainable materials

Sustainable systems policy can support low-emission, efficient and resilient buildings goals by enabling market transformation that increases the availability of sustainable products. Within the targets for sustainable materials, the following sub-activities offer more detail.

4.5.2.1 Information and awareness

Definition of activity

Combining information and capacity building activities can increase the overall awareness of people to improve their decision-making process. Product labels on all systems sold can provide information on the sustainability of the products including their embodied energy and carbon and their lifecycle energy and carbon performance. Supporting the information rollout with educational efforts to increase the capacity for people to make better design, purchase, and operational decisions.

Describing sub-roadmap

1. Step 1: Empower a technical working group (composed of national officials, manufacturers and experts). Collect data on material characteristics, to structure this task it is recommended to review existing international (and regional used) norms and tools. Then agree on the best matching norm for the specific country context
2. Step 2: Develop a platform (database) or select an existing one to gather the data. Focus on the first most relevant data for the regional context
3. Step 3: Train and inform experts on LCA principles and the utilization of the database.
4. Step 4: Increase the outreach to other relevant stakeholders and make use of synergies with other programmes, which are described later in the report (e.g. benchmarking, material labelling and minimum environmental standards)

Describing the status quo of tier groups

- Early Development: No relevant awareness campaigns or capacity building measures on sustainable construction materials are available.

- **Moderate Development:** Few initiatives are present indicating the start of first steps for the consideration of LCA. Currently no policies or official regulations control LCA activities. Early stages regarding awareness and supporting less embodied energy materials, LCA and carbon performance.
- **Advanced Development:** There are initiatives / projects that have picked up the topic – but still no awareness campaign has been launched.

Next steps

- **Early:** Empower a technical working group (composed of national officials, manufacturers, and experts) and collect data on material characteristics.
- **Moderate and Advanced:** Coordinate the private sector driven initiatives with national strategies. Expand the training of experts and awareness campaigns for LCA principles / sustainable construction materials to increase your outreach.

4.5.2.2 R&D

Definition of activity

Increasing research funding can enable the development of local materials production and supply chains, improved processes, practices and services while also increasing their economic competitiveness and their diffusion. Collective R&D efforts fostering cooperation and collaboration instead of competition can enable better allocation of resources, and a faster uptake of innovation as research outcomes are shared across the different countries.

Describing sub-roadmap

1. **Demonstration:** The first step includes the installation of pilot project(s) to prove the technical feasibility of the technology. These pilots should be fully monitored and analysed allowing the formulation of improvements to prepare for the next phase. This step is fully subsidised by R&D related grants.
2. **Pre-commercial:** The second step should build on the learnings of the first phase and allow a (smaller) replication of the pilots, testing them in other locations and improve them while harvesting from the first learnings. It's recommended to seek for an engagement of the private sector and to jointly perform the installation of the next round of pilots. This could allow the future evolvement of spin outs and allow the sequential reduction of investment risks.
3. **Supported commercial:** The third step is the stage where, given renewables support the roll- out in substantial number and by commercially oriented companies.
4. **Mainstream:** In the last step the technologies can compete unsupported in the market and are becoming mainstream.

Describing the status quo of tier groups

- **Early Development:** The research activities on sustainable materials are rather limited to some specific projects, like the example of a UN-Habitat for Internal Displaced Persons (IDPs), where the environmentally friendly durable, cost-effective Stabilised Soil Blocks (SSBs) technology were introduced for the reconstruction of public facilities. (UN Habitat 2019b)
- **Moderate Development:** There are signs indicates the possibility of the development of materials research. Several partnerships with local and international universities,

laboratories and joint programmes with international entities display the actions that support the R&D in the field of materials. Still no policies are available for the R&D.

- Advanced Development: some solid researches on material, such as the research on the production of green concrete in the UAE, issued in 2018 by Syed Talha Muhammad Ali & Mustafa Batikha under the title “Producing Green Concrete by Using Recycled Materials in UAE” (Ali and Batikha 2018). Research and development (R&D) policy and research and development council are established to strengthen the performance and effectiveness of the science and technology (S&T) sector and its efforts to achieve a knowledge-based economy.

Next steps

- Early: Extend the installation of pilot project(s) to prove the technical feasibility of the technology and the monitoring of the results
- Moderate: Foster the testing and piloting of sustainable materials and connect private led initiatives with public sector driven strategies
- Advanced: Consider in the introduced R&D Governance Policy as well a focus on sustainable materials and seek the collaboration with the private sector

4.5.2.3 Benchmark and disclosure

Definition of activity

To monitor progress, understand best practices and to facilitate better decisions at the design stage and in policymaking, benchmarking coupled with data disclosure will be of importance. Data disclosure requirements could build on experiences with material passports and other initiatives such as the CDP.⁷ Disclosure of the environmental impacts and efficiency levels of building projects should be developed in order to ensure a better enforcement of regulations.

Describing sub-roadmap

1. Elaborate a study analysing the most relevant environmental indicators relevant for the region and starting with most relevant construction materials. And create benchmark study that clearly illustrates min., max. and median per indicator. This can be done on materials level, but as well on building component level (e.g. external wall, roof, floors etc.)
2. Based on the learnings derived from the benchmarking study a voluntary classification system can be introduced. Aiming to exclude the “bad performing” materials and shifting the median of the ecological indicators towards the best in class.
3. Monitor and report the progress. Afterwards evaluate the process to further improve the voluntary classification system (e.g. Material passport).

Describing the status quo of tier groups

- Early, Moderate, Advanced: No benchmarking studies have been conducted that illustrate the environmental indicators of construction materials.

Next steps

- All: Elaborate a study analysing the most relevant environmental indicators relevant for the country starting with most relevant construction materials. Create a benchmark study that clearly illustrates min, max, and median per indicator.

4.5.2.4 Material labelling

Definition of activity

Product labels on materials and components can provide information on the sustainability of the products, including their embodied energy and carbon, in ways that can be used in a lifecycle carbon assessment. EPDs and Health Product Declaration (HPDs) are some of the different voluntary labelling systems available currently supporting the information rollout with educational efforts to increase the capacity for people to make better design, purchase and operational decisions. The creation of EPDs for buildings and construction materials and products and their use in design is voluntary in most regions and countries. Some European countries, such as Finland, France, and the Netherlands, are moving towards legislative adoption of LCA requirements for the construction industry, which is expected to be a catalyst for wider market penetration of EPDs (WorldGBC, 2019).

Describing sub-roadmap

The following sub-roadmap was quoted from the webpage of the EPD International secretariat (<https://environdec.com/all-about-epds/create-your-epd>) and the main steps are illustrated in the following:

1. Before developing an EPD, a suitable Product Category Rules (PCR) must be chosen.
2. When developing the EPD, the environmental performance of the product shall be described from a life cycle perspective where one of the main steps is to carry out a life cycle assessment (LCA) of the product.
3. The results of the LCA study and other information mandated by the reference PCR and General Programme Instructions shall be compiled in the EPD reporting format.
4. The verification process shall be carried out by an approved individual verifier or an accredited certification body with knowledge and experience of the types of products, the industry, and relevant standards of the product covered by the EPD and its geographical scope.
5. After completed verification, the organisation developing the EPD shall register the EPD in the EPD Portal together with other mandatory documentation.

Describing the status quo of tier groups

- Early Development: As confirmed through interviews, no material labelling is available.
- Moderate Development: Few initiatives are present indicating the start of first steps for the consideration of LCA. Currently no policies or official regulations control LCA activities. Early stages regarding awareness and supporting less embodied energy materials, LCA and carbon performance.
- Advanced Development: Availability of products that complies with green building standards, as initiatives without a defined policy regulating the materials' labelling. According to EPD International library, limited number of products are registered in the EPD system.

Next steps

- Early: Start with the development or selection of appropriate PCR
- Moderate: Increase the range of local products that have a PCR and EPD. Start to ask for EPDs in public building projects.

- Advanced: Increase the range of local products that have a PCR and EPD

4.5.2.5 Minimum environmental standards

Definition of activity

The successive development and expansion of voluntary schemes towards mandatory minimum environmental standards for materials would effectively create markets for low-emission products. Testing protocols and standards for materials (including new materials) will have to be developed. Building codes, where in place, should include minimum environmental performance standards for materials to be used or, via performance requirements, encourage use of low-carbon materials. Stringency should be increased over time to continue to drive the market further towards low-carbon solutions.

Describing sub-roadmap

1. Based on the sub-roadmap described previously (Materials – Benchmarking) build on the experiences gathered for the voluntary scheme and transform it to a mandatory scheme asking for minimum environmental standards. This step needs to be accompanied by capacity building measures such as trainings and awareness rising campaigns.
2. The progress needs to be monitored and reported. The specific KPIs should be evaluated, and the previous step needs to be redesigned if the targets are not met.
3. With time the benchmarks need to be tightened, more environmental indicators can be added and further products can be complemented.

Describing the status quo of tier groups

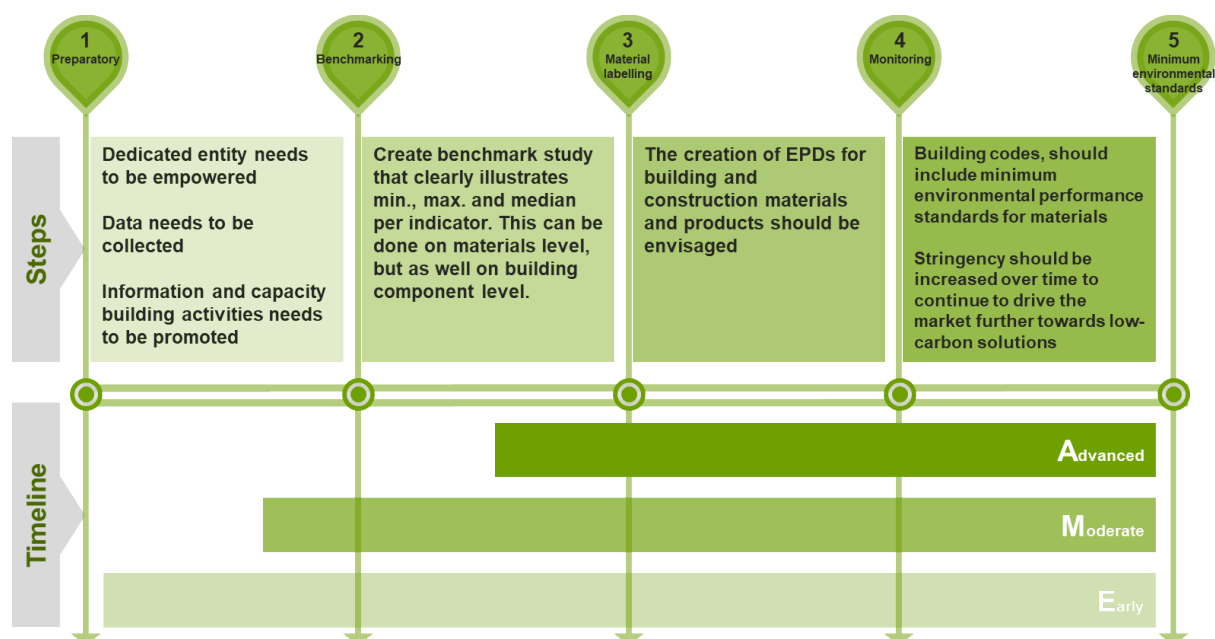
- Early Development: No minimum environmental standards are available.
- Moderate Development: Available standards for different building materials and materials from other different sectors. These standards include the minimum performance requirements for each material, but the environmental performance is not mentioned as part of their standards.
- Advanced Development: Available as part of the green buildings' guidelines with defined requirement for materials and waste. It covers the procurement of sustainable materials, use of quality materials, regional materials and embodied carbon guidelines to limit the negative environmental impacts associated with buildings' material.

Next steps

- Early, Moderate: An introduction, starting a few but most relevant products , should be envisaged.
- Advanced: The request for EPDs by the ministerial guidelines should be increased from 5 EPDs to 10 and expanded to other building types.

4.5.2.6 Sub-conclusion

Figure 28 shows the main (aggregated) steps to decarbonise the policy for Activity 6. The bottom half of the figure illustrates the mapping of the three development phases and the upper half shows the recommended steps.



Key message: LCA requirements for the construction industry as a catalyst for wider market penetration of sustainable construction materials

Figure 28. Roadmap for Activity 6 – materials, policy.

4.5.3 Technology for sustainable materials

The energy use and emissions from buildings are influenced by the materials used in the buildings. Specific sub-activities for the sustainable materials are outlined in the following sections.

4.5.3.1 Material (resource) efficiency

Definition of activity

Reducing primary material demand through optimised design, optimised building techniques, the more intensive use of existing materials and the reuse of scrap material offers cost-effective measures to reduce embodied carbon of materials. In addition, low-carbon alternative materials already exist for several processes and usages, (such as clinker substitutes for cement production or timber instead of steel in construction) and should be strongly encouraged and incentivised. Other examples include promoting concrete-steel composite construction, reducing cement content in concrete and lower clinker -to-cement ratio. Precautionary steps would have to be taken to prevent negative effects (e.g. promoting the use of timber might increase demand for wood that will have to be met by sustainable harvesting).

Describing sub-roadmap

1. Formulate a SMART objective that aims to widespread the adoption of low- carbon alternatives and material-efficient designs related to your specific country context.
2. Develop a baseline study that defines what are the most consuming and emitting industry in your country. Then research regional/ international best practice examples. Finally work out feasibility studies for top three manufactured materials.
3. Start with the implementation of pilot(s) that make it possible to optimise the material use with improved design and construction methods and encourage the prioritisation of low-carbon materials.

4. Monitor and report the learnings of the pilots and formulate guidelines for designers and manufacturers on alternative materials or processes developed and train experts in your country.
5. Analyse carefully the results of the pilots and trainings and learn from the experience, to improve the next pilots and training curricula. Upscale to reach commercial scale and finally mainstream.

Describing the status quo of tier groups

- Early Development: No material efficiency technology is available in the buildings sector.
- Moderate Development: Few initiatives towards materials efficiency. Such as decreasing the carbon emission from the cement industry by using alternative fuels and raw materials and waste heat recovery.
- Advanced Development: Legislations to enforce the use of efficient materials. Such as the green cement, which is a material that meets or exceeds the functional performance capabilities of ordinary Portland cement by incorporating and optimising recycled materials, thereby reducing consumption of natural raw materials, water, and energy, resulting in a more sustainable construction material.

Next steps

- Early and moderate: Start with a clear vision and strategy formulation. Then build up a database to base your decisions. Focus on top three materials.
- Advanced: Work on dissemination and capacity building to increase awareness and capabilities. Then expand the scope of materials that should be made more resource efficient.

4.5.3.2 Energy efficiency in material production

Definition of activity

Indicators to monitor specific energy use for the production and processing of material and components should be established, tracked, and compared with BATs. This will allow the setting of targets for manufacturers and set minimum standards. Current BATs should be promoted across all sectors. Further measures to improve energy efficiency include making Energy Management System - EMS (such as the ISO 50001) compulsory, promoting industry networks (to share best practices, identify energy efficiency potentials, set targets, etc.), and promoting access to and uptake of sustainable manufacturing technologies.

Describing sub-roadmap

1. Encourage the rollout of energy audits of all manufacturing facilities resulting in a benchmark and spotting the most energy intensive manufacturing process
2. Set specific targets set for key subsectors and support bad performers to reduce their energy consumption. Several instruments are possible (push – regulation or CO₂ pricing or pull – like financial incentives) depending on the country-specific situation.
3. Identify current BAT for the most relevant sectors and implement them as well as mandatory energy management systems.
4. Monitor and evaluate the progress and report the KPIs. Learn from the achievements and failures, to improve the developed programme and widespread an energy efficient manufacturing and supply chain

Describing the status quo of tier groups

- Early Development: No actions towards energy efficiency in material production is available.
- Moderate Development: Based on the same source mentioned under the material (resource) efficiency, the focus is on energy efficiency in the production as improving thermal energy efficiency and waste heat recovery. No further steps were taken in the energy efficiency in material production of buildings sector.
- Advanced Development: ISO 50001 certification is available, which mandates organisations to comply with a set of guidelines to better manage energy resources and consumption. No enforcement of this certification is available in the field of materials production.

Next steps

- Early: Start to benchmark your local manufacturing industry and perform energy audits to identify energy-saving potentials.
- Moderate: Start to benchmark your local manufacturing industry and perform energy audits to identify energy-saving potentials. Learn from the first implemented pilot(s) and document the progress.
- Advanced: Enforce energy management systems to all manufacturing premises.

4.5.3.3 Decarbonising materials production

Definition of activity

The extensive use of renewable energy can be challenging in various industrial processes. However, by tracking the embodied carbon of materials, manufacturers will be encouraged to shift towards cleaner energy mixes (e.g. gas instead of coal, electrification of processes, use of hydrogen) and develop innovative solutions to maximise the use of waste heat and alternative sources of energy, or even waste material as fuel. These areas show great potential in sectors such as the cement and steel industries.

Describing sub-roadmap

1. Formulate a SMART strategy: that set targets for the decarbonisation of heat and electricity allowing a widespread of decarbonised industrial processes and power systems.
2. Conduct feasibility studies checking different clean energy technologies like biomass, waste heat recovery strategies, electrification of processes, and the switch to cleaner fuels and hydrogen.
3. Begin to test the implementation of clean energy in manufacturing premises using pilots.
4. Monitor, report, and evaluate the progress and upscale the successful pilots and improve the suboptimal tests/pilots.

Describing the status quo of tier groups

- Early Development: Decarbonising material production is not available.
- Moderate Development: is still in the initiation steps for the decarbonisation of the energy sector in general, so the steps are still in the beginning and the official inclusion of

decarbonising of material production may initiate in the next steps. Incremental inclusion of renewable energy in the industrial sector is on-going.

- **Advanced Development:** Few initiatives are available for decarbonising materials production, such as the reuse of waste in the industry of building material production, and the use of RE such as solar power as power source for the production process.

Next steps

- **Early and moderate:** Identify the most important manufacturing premises and draft a sector-specific roadmap to integrated clean energy in the process.
- **Advanced:** Learn from implemented pilots, document the learnings and use for upscaling.

4.5.3.4 Locally produced materials

Definition of activity

Embodied carbon can be reduced by promoting the development of local low-carbon industry to produce building materials where appropriate as determined by LCAs. This should be paired with new building methods, demonstration projects and case studies. Mapping of material flows, and inventories of embodied carbon could support such a development.

Describing Sub-roadmap

1. Collect data about traditional building methods and materials
2. Combine old techniques with new ones to make them more efficient. Test the implementation with pilots.
3. Incentives to encourage the use of local materials rather than imports, used where appropriate
4. Monitor and report the most relevant KPIs like the calculated resource efficiency.

Describing the status quo of tier groups

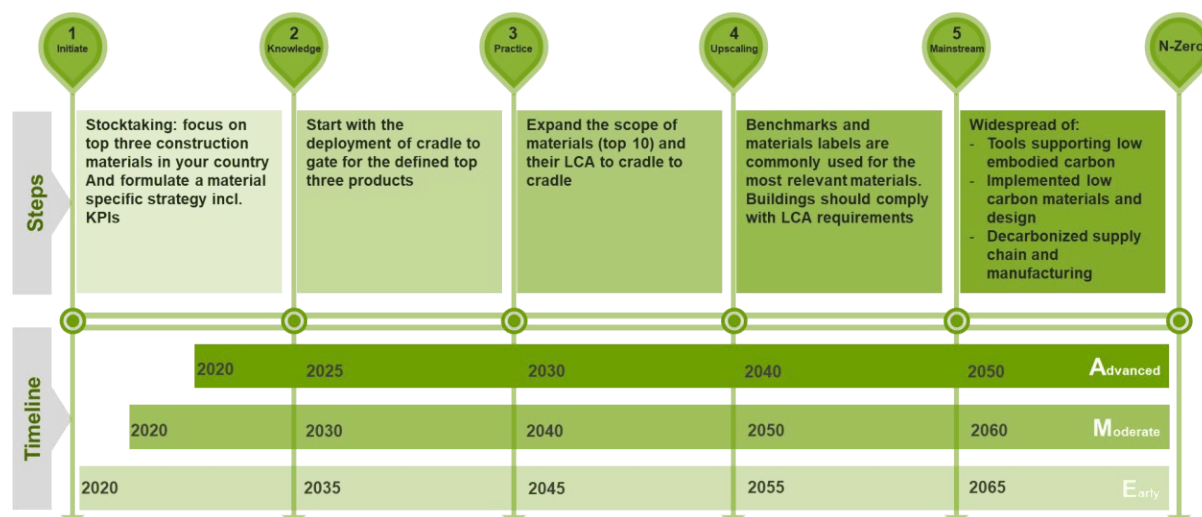
- **Early Development:** Locally produced materials are not available.
- **Moderate Development:** The government shows serious support to the wider production of local materials , but still the market widespread is very low.
- **Advanced Development:** Guidelines for green buildings mandates that at least 10% of building materials shall have been extracted, harvested or recovered, as well as manufactured, within 800 km of the project site based on cost. If only a fraction of a product or material is extracted, harvested, or recovered and manufactured locally, then only that percentage (by weight) can contribute to the regional value.

Next steps

- **Early:** Start with data collection and evaluate the comparison of business-as-usual construction techniques and alternative pathways.
- **Moderate:** Ask for a minimum share of locally produced materials for all public buildings.
- **Advanced:** Increase the share of locally produced materials for all public buildings and extend the requested share gradually as well to other building types.

4.5.3.5 Sub-conclusion

Figure 29 shows the main (aggregated) steps to decarbonise the technology for Activity 6. The bottom half of the figure illustrates the mapping of the three development phases and the upper half shows the recommended steps.

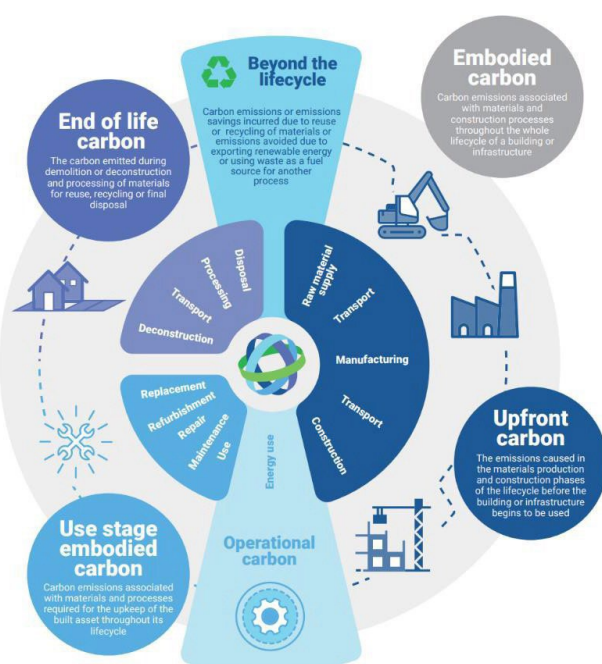


Key message: A gradual rollout of LCA requirements to implement sustainable construction materials

Figure 29. Roadmap for Activity 6 – materials, technology

4.5.4 Best practices and resources for materials

Policy/Planning: Reducing embodied carbon emissions

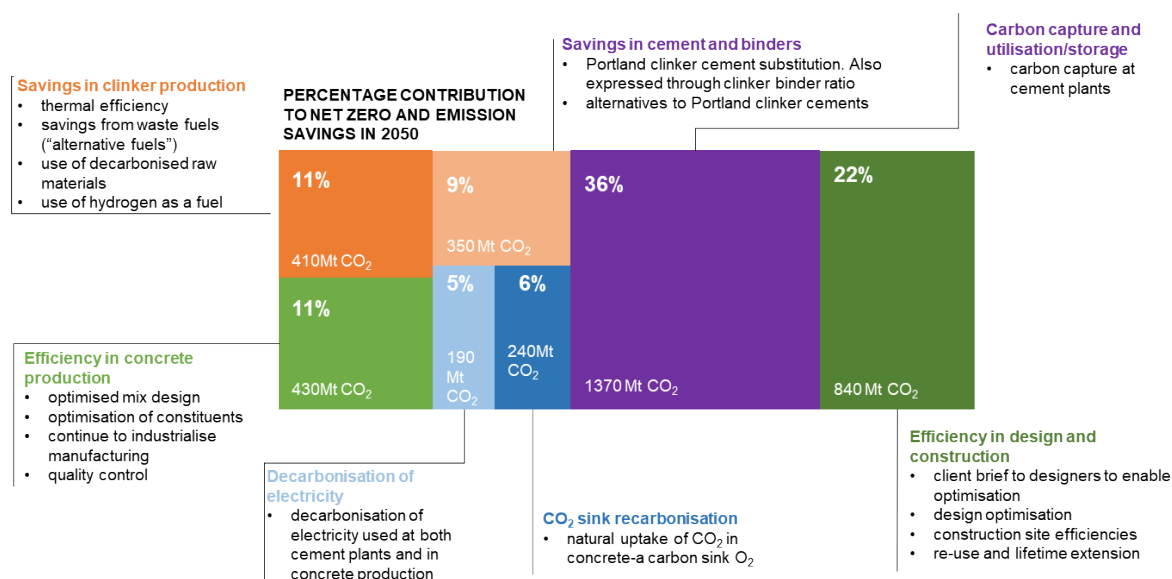


Embodied carbon emissions are associated with materials and construction processes throughout the whole lifecycle of a building or infrastructure. As operational carbon is reduced, embodied carbon will continue to grow in importance as a proportion of total emissions. To address the issues of embodied carbon upfront (i.e. before the building or the infrastructure is used), Global ABC envisions, to spark a global conversation around the importance of net-zero embodied carbon. The consideration of whole lifecycle concepts is getting more and more crucial.

Source:

https://www.worldgbc.org/sites/default/files/WorldGBC_Bringing_Embodied_Carbon_Upfront.pdf

Technology/Implementation: GCCA Concrete Future Roadmap



Source: <https://gccassociation.org/concretefuture/wp-content/uploads/2021/10/GCCA-Concrete-Future-Roadmap-Document-AW.pdf>

By 2050, the Global Cement and Concrete Association (GCCA) envisions accelerating its CO₂ reductions (reaching net-zero) through actions such as increased material substitution, increased energy efficiency, decarbonising its electricity demand, carbon capture utilisation/storage and others. This is a good example illustrating how a specific industry foresees its decarbonised future.

4.6 Activity 7: Resilience

The fragility in the region is shaped by the unique situation of linked challenges of water scarcity, drought, food insecurity, population growth, social vulnerability, rapid urbanisation, low resilience levels and conflict. (UNDRR regional assessment report, 2021)

Through the Sendai Framework for Disaster Risk Reduction, countries are engaged in taking measures to reduce disaster risks. Climate and climate change affects construction in three ways:

- They have a relevant influence on construction delays and thus costs.
- As the climate changes, buildings' and building materials' design standards will have to change to withstand the new weather conditions
- As the pattern of natural disasters changes, a change in the demand for rebuilding and repair will occur.

Upgrading the durability and resilience of all buildings by gradually addressing the most critical infrastructures (e.g. having a social and economic relevance, like hospitals, emergency facilities, schools, power plants, hazardous material facilities, etc.), followed by the most vulnerable buildings (e.g. in regions susceptible to natural disasters and extreme weather) and the remainder of the building stock. The following lists three key actions for each development phase:

4.6.1 Key actions for resilience

Key actions to enable increased resilience for buildings in early starter countries include:

- Conduct a risk mapping and impact assessment. Define a set of criteria to assess the sensitivity and adaptive capacity of buildings. Support national and local administrations to identify main climate risks associated with buildings. Map climate events according to their certainty of impacts in a specific region.
- Develop a resilience strategy to identify policies and measures. Generate a clustering of regions as starting point for a resilience strategy. Develop guidelines as important step to an overall resilience strategy.
- Improve buildings resilience to climate change. Define locally appropriate measure to improve buildings resilience to climate change. Develop instruments and tools to support sustainable building design and renovation. Increase knowledge on specific construction measures

Key actions to enable increased resilience for buildings in moderate countries include:

- Conduct a risk mapping and impact assessment. Define a set of criteria to assess the sensitivity and adaptive capacity of buildings. Map climate events according to their certainty of impacts in a specific region. Use climate vulnerability and risk assessment (CVRA) methodology.
- Develop a resilience strategy to identify policies and measures. Develop guidelines as important step to an overall resilience strategy. Initiate monitoring strategies and work effectively with stakeholders.
- Improve buildings resilience to climate change. Develop specific regional guidelines for relevant actors. Describe specific requirements for buildings and built areas and work on regulations to establish mandatory requirements for specific risk areas.

Key actions to enable increased resilience for buildings in advanced countries include:

- Conduct a risk mapping and impact assessment. Monitor acute events in the context of durability and resilience of building structures. Evaluate quality and range of risk and impact assessments.
- Develop a resilience strategy to identify policies and measures. Define criteria for rating resilience of buildings. Based on an overall Disaster Risk Reduction Plan develop a resilience strategy. Evaluate the state of resilience measures and activities for the buildings sector of your country
- Improve buildings resilience to climate change. Setup regulations to establish mandatory requirements for specific risk areas. Create financing mechanisms for resilience measures to support the implementation. Monitor implementation and initiate enforcement schemes for mandatory requirements

4.6.2 Stakeholders for resilience

In the Arab region, the key stakeholders for resilience include those that can influence the ability to make technologies and design approaches available to increase resilience of buildings and those that can deliver the results of resilient buildings. Additional stakeholders include those that can support the process through research, funding, and training. All these stakeholders are essential to delivering on roadmap targets. Table 10 shows the stakeholders; the darker the colour of the cell, the more effective the stakeholder is. The key stakeholders are marked in bold.

Table 10. Stakeholders for resilience

Stakeholders	
National government	Sustainable service providers
Subnational government	Civil society
Implementing and enforcement agencies/actors	Sustainable product/material providers
Building authorities and housing associations	Researchers
Architects and engineers	Financial institutions
Property developers	Training and capacity institutions/providers
Utility companies and municipal service authorities	Business associations

4.6.3 Policy for resilience

Sustainable building resilience policy can support low-emission, efficient and resilient buildings goals by enabling market transformation that increases the usefulness and life of sustainable buildings. Within the targets for sustainable building resilience, the following sub - activities offer more details:

4.6.3.1 Risk mapping and impact assessment

Definition of activity

Gather and document data related to land use plans incorporating natural hazards (e.g. landslides, earthquakes) and climate-related risks (e.g. flooding, heatwaves), emergency plans, existing community plans, ordinances and codes, maps and data on geographic location of critical infrastructure systems or facilities, community utility needs (e.g. energy, water, and fuel use and generation), and climate preparedness plans. Requirement for climate change impact assessments, on changes in typical and extreme weather events (storms, cloud patterns, precipitation, and temperatures).

Describing sub-roadmap

1. Preparatory steps: Support national and local administrations to identify main climate risks associated with buildings. In order to undertake a vulnerability assessment, first a full set of criteria needs to be identified in the buildings sector that will support the assessment of sensitivity and adaptive capacity.
2. Strategy and conception: Map climate events according to their certainty of impacts in a specific region. The mapping should include the likeliness of climate events in a certain region and the vulnerability of local buildings as well as the number of affected buildings. Increase awareness of the associated stakeholders of the buildings sector to climate change and its potential consequences.
3. Instruments: Implement assessments of the specific vulnerability of regions or municipalities. Use climate vulnerability and risk assessment (CVRA) methodology specifically adjusted for buildings and blocks of buildings. The assessment of climate impacts, vulnerability and risks should include:
 - a. Overview of observed climate hazards and existing pressures.
 - b. Identification of key future climate hazards and key affected sectors.

This step should be accompanied by capacity building activities targeting municipal responsible staff, engineers and building project developers.

Rated qualitative scales of impact for affected sector, including likelihood of the occurrence of key hazards and exposure of buildings, vulnerability, and adaptive capacity of new and existing buildings.

The risk mapping and impact assessment should consider using methodologies and tools of climate modelling. The methods and tools provided by IPCC can be a good starting point to develop locally detailed and suitable climate modelling methods and tools.

4. **Monitoring:** Monitor acute events in the context of durability and resilience of building structures such as intense floods, cloudbursts, droughts, heatwaves, wildfires, storms and landslides. Include chronic events like sea-level rise, changes in precipitation, soil moisture and air humidity having impact on buildings and inhabitant of effected areas as well.
5. **Evaluation:** Evaluate quality and range of risk and impact assessments. Assess stakeholder preparedness and communication on risks and outcomes of impact assessments.

Describing the status quo of tier groups

- **Early Development:** N/A
- **Moderate Development:** Risk mapping actions are not taking place. Limited actions such as the focus on the climate change impacts on coastal zones and the water availability situation.
- **Advanced Development:** Risk mapping action and mentioning of the impact of climate change on buildings and the potential damage and deterioration is developed. The required action has to be taken in the phases of design. Also, construction and retrofitting as well as the cooling loads as well as the energy use patterns have to be evaluated.

Next steps

- **Early:** Define a set of criteria to assess the sensitivity and adaptive capacity of buildings. Support national and local administrations to identify main climate risks associated with buildings. Map climate events according to their certainty of impacts in a specific region.
- **Moderate:** Define a set of criteria to assess the sensitivity and adaptive capacity of buildings. Map climate events according to their certainty of impacts in a specific region. Use climate vulnerability and risk assessment (CVRA methodology).
- **Advanced:** Monitor acute events in the context of durability and resilience of building structures. Evaluate quality and range of risk and impact assessments.

4.6.3.2 Resilience strategy

Definition of activity

Develop a resilience strategy that identifies the list of policies and measures that can support increased resilience and addresses the potential for relocation and crisis plans for high-risk settlements. All countries should develop national resilience strategies, and all jurisdictions should develop local resilience strategies. Resilience strategies should include planning for critical infrastructure (hospitals, schools, water supply, energy supply, etc.). Resilience strategies should also include requirements for “building back better” during reconstruction

after a disaster. An example of the types of measures to be included within a resilience strategy in a low-lying coastal area would be coastline retreat management.

Describing sub-roadmap

1. Preparatory steps: Carry out a clustering of regions to address the diverse regions with the matching adaptation strategy for buildings. The predefined macro-regions represent a first approach to a climatological distinction. In addition, other more specialised areas like riverbanks, shorelines, urban agglomerations need to be addressed separately.
2. Strategy and conception: Develop guidelines as important step to an overall resilience strategy and highlight the benefits of more resilient buildings. The guidance should help decision makers to define efficient approaches for appropriate monitoring strategies and in working effectively with stakeholders.
3. Instruments: Based on an overall Disaster Risk Reduction Plan, develop a strategy to promote the uptake of measures and practices that ensure buildings are more resilient and better equipped to deal with changing climate. The portfolio of instruments addressed should include concrete requirements in terms of a more resilient buildings sector, financial measures, communication measures and overall risk and vulnerability mapping and monitoring activities. This step should be accompanied by capacity building activities.
4. Monitoring and reporting: Define criteria for rating resilience of buildings or urban areas. In combination with the vulnerability assessment of a respective area, climate adaptation activities or measures need to be taken into account to assess the overall resilience of an area or region.
5. Evaluation: Evaluate the state of resilience measures and activities for the buildings sector of your country.

Describing the status quo of tier groups

- Early Development: The availability is limited to some initiatives to enhance the resilience for the residents of some areas.
- Moderate Development: Few initiatives are in place, including PV cells for off-grid villages, the adoption of an NEEAP, conversion to LED lamps and implementing standards and labelling programme for home appliances. Still no policies are available dealing with strategies for reconstruction after a disaster.
- Advanced Development: Risk assessment & options for action are developed. The classification of the status quo on risks and their effect on the infrastructure and buildings sector were identified including: Damage to coastal and offshore infrastructure, Increased infrastructure maintenance costs, loss of business opportunities due to transport disruptions, and reduced reliability of transport infrastructure and buildings. A more focused highlight included the concentration on the cooling loads and how it creates pressure on the grid. Still the data about different risks are mapped and analysed but an official strategy of resilience is still not available.

Next steps

- Early: Generate a clustering of regions as starting point for a resilience strategy. Develop guidelines as important step to an overall resilience strategy. Develop monitoring strategies and work effectively with stakeholders.

- Moderate: Develop guidelines as important step to an overall resilience strategy. The portfolio of instruments should include concrete requirements like financial measures, communication, risk and vulnerability mapping and monitoring activities.
- Advanced: Define criteria for rating resilience of buildings or urban areas. Based on an overall Disaster Risk Reduction Plan develop a resilience strategy. Evaluate the state of resilience measures and activities for the buildings sector of your country.

4.6.3.3 Resilience in building codes

Definition of activity

Incorporate measures in building codes to increase structural and thermal resilience, including passive measures that enable occupants to use buildings when energy services are not available in an extreme weather event or natural disaster. This includes insulating, shading, load bearing roofs, wind and seismic proof walls and water drainage and storage systems.

Describing sub-roadmap

1. Preparatory steps and strategy: Analyse options to include resilience requirements into building codes. Respective requirements could refer to adaptation planning (exposure to climate impacts), resource use (specific material) and performance aspects (adaptive capacity) of new buildings.
2. Strategy and conception: Identify relevant improvements that could be implemented via building and urban planning codes. Institute capacity building of relevant stakeholders to increase climate resilient planning and construction.
3. Instruments: Include requirements for climate resilience in building codes and make sure all new buildings are reached in an effective way. Ensure that buildings are not built-in areas prone of flooding, fire or erosion. Define a building design that is suitable for climate hazards such as fire or flooding and accounts for changing climate by regulating the size and exposition of apertures and shading elements. Include features that increase resilience to events like fire-retardant elements, drainage routes, reinforced roofs, insulating materials. This step should be accompanied by capacity building activities targeting municipal responsible staff, engineers and building project developers.
4. Monitoring and reporting: Monitor implementation and enforcement of building code requirements. Guide public and private stakeholders involved in the planning and design phase to comply with resilience requirements.

Describing the status quo of tier groups

- Early, Moderate, and Advanced: Resilience is not covered in building or energy efficiency codes.

Next steps

- Early: Analyse options to include resilience requirements into building codes for new and existing buildings. Identify relevant improvements that could be implemented via building and urban planning codes. Institute capacity building of relevant stakeholders to increase climate resilient planning and construction.
- Moderate: Identify relevant improvements that could be implemented via building and urban planning codes. Institute capacity building of relevant stakeholders to increase

climate resilient planning and construction. Include requirements for climate resilience in building codes and make sure all new buildings are reached in an effective way.

- Advanced: Define a building design that is suitable for climate hazards. Include features that increase resilience to particular events like fire-retardant elements, drainage routes, reinforced roofs, insulating materials. Include requirements for climate resilience in building codes. Monitor implementation and enforcement of building code requirements.

4.6.3.4 Adaptation programmes for existing buildings

Definition of activity

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

Describing sub-roadmap

1. Preparatory steps: Create commitment and political will as precondition for adaptation activities for existing buildings and high-risk areas. Get all relevant actors involved dealing with planning aspects linked to the arrangement of (informal) settlement structures to develop legal and institutional frameworks for respective land use plans. Include local authorities and communities of high-risk areas into the communication stream.
2. Strategy and conception: Develop strategies for maintenance and operation of existing buildings with focus on adaptation to climate change. Since climate hazards are affecting more buildings and built areas now and, in the future, the adaptive capacity of existing buildings needs to be increased. Strengthen the knowledge on climate impacts and respective resilience measures of tenants, owners, and local communities.
3. Instruments: In combination with the vulnerability assessment of the respective areas, diverse climate adaptation activities or measures should be in place in all relevant high-risk areas. Assessments of the buildings adaptive capacity need to be taken into account. Provide an approach to define a rating system as process-oriented or result-oriented approach. This step should be accompanied by capacity building activities.
4. Monitoring and reporting: Monitor climate impact on existing buildings. Assess adaptive capacities and measures taken to increase resilience of buildings in vulnerable areas. A country-wide monitoring system should be in place.
5. Evaluation: Evaluate country-wide process and development in terms of adaptation measure for vulnerable areas. Use national monitoring system as basis to evaluate progress. Further scale up approach and continue process in all relevant regions as well as informal settlements.

Describing the status quo of tier groups

- Early Development: Based on the report from UN-Habitat issued in 2019 about the collaborative project with Norway of “Promote Peace Building and Stability in the Blue Nile”, the displacement of population that was affected by wars and conflicts to more to more decent environment for living occurred (UN Habitat 2019b).

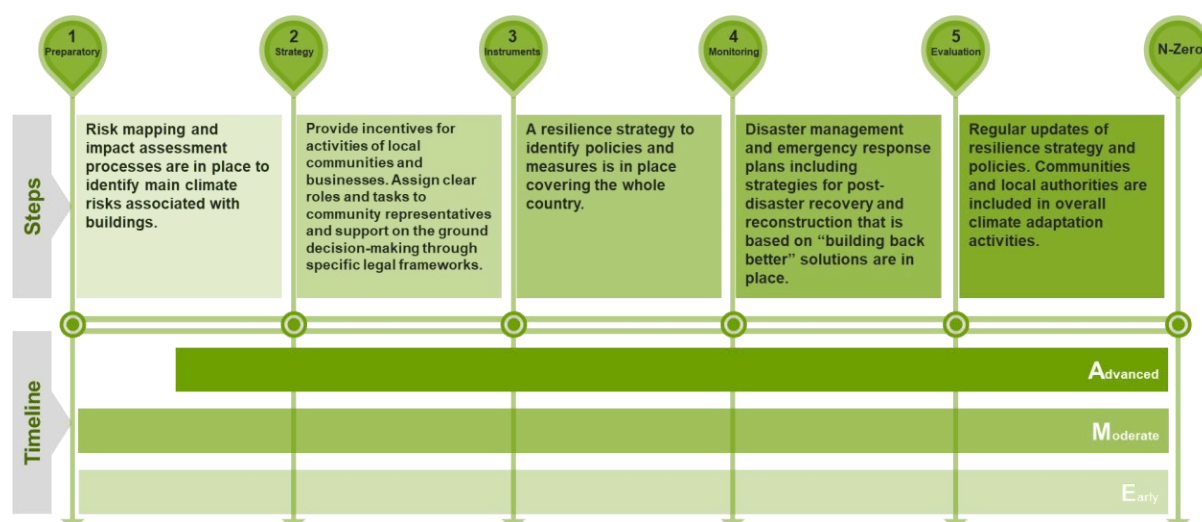
- **Moderate Development:** Informal settlements development fund is established, with a target to deal with the different cases of informal settlements in terms of upgrading, development, or rehabilitation.
- **Advanced Development:** Risk assessment is developed. all risks were categorised and among the high risk group was the damage for the coastal infrastructure and the adaptation measures included: physical safe guards e.g. building set-backs, risk management e.g. enhancing design standards for coastal buildings, knowledge e.g. promoting awareness about coastal infrastructure, and enablers e.g. reviewing property valuation including ecosystem and its rehabilitation costs.

Next steps

- **Early:** Create political will for adaptation activities of existing buildings and high-risk areas. Get all relevant actors involved dealing with planning to develop legal and institutional frameworks for respective land use plans.
- **Moderate:** Develop strategies for maintenance of existing buildings with focus on adaptation to climate change. Include local authorities and communities of high-risk areas into the communication stream. Provide an approach to define a rating system for existing buildings.
- **Advanced:** Climate adaptation measures should be in place in all relevant high-risk areas. Assess adaptive capacities and measures taken to increase resilience of buildings in vulnerable areas. A country-wide monitoring system should be in place.

4.6.3.5 Sub-conclusion

Figure 30 shows the main (aggregated) steps to decarbonise policy for Activity 7. The bottom half of the figure illustrates the mapping of the three development phases and the upper half shows the recommended steps.



Key message: Supporting detailed targets can enable the broader sustainable development goals.

Figure 30. Roadmap for Activity 7 – resilience, policy.

4.6.4 Technology for resilience

The lifecycle energy and emissions for buildings are influenced by the resilience of the building and its components. Specific sub-activities for resilience are outlined below:

4.6.4.1 Information systems and monitoring

Definition of activity

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

Describing sub-roadmap

1. **Initiate:** Promote the collection, analysis, management and use of relevant data and practical information and ensure its dissemination. Allocate necessary resources at all levels of administration for the development and the implementation of disaster risk reduction database.
2. **Knowledge:** Support local authorities with setting up local resilience plans. Strengthening disaster risk governance to manage disaster risk. Improve dialogue and cooperation among scientific and technological communities, all relevant stakeholders, and policymakers. Establish training and education measures.
3. **Practice/upscale:** Offer location-based disaster risk information, including risk maps as GIS-based data for the whole country. Share open data with local level, with public and private stakeholders. Invest in disaster risk reduction in terms of resilience measures.
4. **Mainstream/monitor:** Trace data changes, climate events and impacts and update country-wide database on a regular basis. Evaluate and share information on disaster losses. Promote the strengthening of international voluntary mechanisms for monitoring and assessment of disaster risks.

Describing the status quo of tier groups

- **Early Development:** No measures were taken with regards data and monitoring.
- **Moderate Development:** No physical steps of data monitoring for risks and warning systems are available.
- **Advanced Development:** Still the Sendai Framework is considered as an initiative. No data about physical tools and monitoring is available.

Next steps

- **Early:** Promote the collection and use of relevant data. Allocate necessary resources for the development of disaster risk reduction database. Strengthening disaster risk governance to manage disaster risk. Improve dialogue among all relevant stakeholders.
- **Moderate:** Allocate necessary resources for the development of disaster risk reduction database. Support local authorities with setting up local resilience plans. Establish training and education measures.
- **Advanced:** Offer location-based disaster risk information as GIS-based data for the whole country. Share open data with local level, with public and private stakeholders. Trace data

changes, climate events and impacts and update country-wide database on a regular basis.

4.6.4.2 Community networks

Definition of activity

The promotion of cohesive and engaged communities is one of the drivers of urban resilience with the most robust empirical evidence (Therrien et al., 2018). As a result, many grassroots groups and local government authorities are actively promoting urban resilience by building tightly knit community networks, in particular in informal neighbourhoods. When community residents and neighbours form close relationships, they can better understand and respond to the changing needs of others—in particular, vulnerable populations like older people and children.

Describing sub-roadmap

1. **Initiate:** Promote a culture of disaster prevention and invest in regional campaigns as instruments for public awareness and education. Share experiences and best practice to generate a common understanding of disaster risk. Encourage public and private stakeholders to actively engage in climate resilience initiatives.
2. **Knowledge:** Disseminate risk information via geospatial information technology. Provide guidance on methodologies for local risk assessments and the use of provided data. Include recommendations and step by step approach in a “community action plan for climate adaptation”.
3. **Practice/upstream:** Provide incentives for activities of local communities and businesses. Assign clear roles and tasks to community representatives and support on-the-ground decision-making through specific legal frameworks. Undertake comprehensive public and community consultations and coordinate “community action plan for climate adaptation” with civil society.
4. **Mainstream/monitor:** Assess technical, financial, and administrative disaster risk management capacity of communities to deal with the identified risks at the local level.

Describing the status quo of tier groups

- **Early Development:** N/A
- **Moderate Development:** No data is available about community networks acting for resilience.
- **Advanced Development:** The role of communities in the early warning systems is not clearly defined due to the lack of knowledge, the unawareness of the national plans.

Next steps

- **Early:** Promote a culture of disaster prevention. Invest in regional campaigns as instruments for awareness raising. Disseminate risk information via geospatial information technology. Provide guidance on methodologies for local risk assessments and the use of data.
- **Moderate:** Encourage public and private stakeholders to actively engage in climate resilience initiatives. Disseminate risk information via geospatial information technology. Provide guidance on methodologies for local risk assessments and the use of provided data. Generate “community action plan for climate adaptation”.

- **Advanced:** Assign clear roles and tasks to community representatives and support on-the-ground decision-making through specific legal frameworks. Undertake comprehensive public and community consultations and coordinate "community action plan for climate adaptation". Assess disaster risk management capacity of communities.

4.6.4.3 Management of extreme weather hazards

Definition of activity

In the wake of Hurricane Sandy and the increase in frequency and severity of climate impacts in urban areas, the paradigm of Design with Nature first conceptualised by Ian McHarg has generated new thinking and momentum. Impervious surfaces in urban areas such as asphalt and concrete constrain natural drainage, exacerbating peak flows and flood risks. In many coastal cities, wetlands are turned into hard surfaces and mangroves are cleared to make space for construction, removing important buffers against floods and storms. By safeguarding natural buffers to enhance ecosystems' protective functions and designing parks and green features (e.g. bioswales), urban planning and landscape design interventions can optimise rain-capture potential and enhance protection from extreme rains (Aponte, 2019).

Disaster risk management practices in the Arab region have traditionally focused on disaster management, with emergency response agencies acting as the focal point for DRM and risk reduction (UNDRR RAR, 2021).

Describing sub-roadmap

1. **Initiate:** Crucial for disaster risk management programmes is an integrated assessment of the region's vulnerability to climate change. Make sure an overall assessment of risks and vulnerabilities is in place. Foster and finance risk management capacity and support regional integration and cooperation.
2. **Knowledge:** Make sure space-related remote sensing techniques are available and in use. Establish regional climate projections and vulnerability maps to identify future risk of weather-related disasters. Create a management platform and early warning systems and communicate tools and systems to all relevant actors.
3. **Practice/upstream:** Build capacities for risk prediction and early warning. Improve decision-making processes to prevent and reduce risks and disaster losses. Establish disaster management units on national and local levels. Develop a disaster management and emergency response plan including strategies for post-disaster recovery and reconstruction that is based on "building back better" solutions.
4. **Mainstream/monitor:** A better understanding of patterns, trends and quantitative indicators of disaster risk is crucial to improve planning and management processes. Assess and monitor the capacity and preparedness of disaster management units. Make sure all preconditions established in the disaster management and emergency response plan are in place.

Describing the status quo of tier groups

- **Early Development:** N/A
- **Moderate Development:** Available as an initiative, such as the improvement to the sewage system to cope with the rainfall in winter in specific cities.
- **Advanced Development:** N/A

Next Steps

- Early: Invest in risk assessments and vulnerability mapping. Foster and finance risk management capacity. Support regional integration and cooperation on disaster risk management.
- Moderate: Invest in risk assessments and vulnerability mapping. Create a management platform and early warning systems. Build capacities for risk prediction and early warning and establish disaster management units.
- Advanced: Establish disaster management units. Develop disaster management and emergency response plans. Generate strategies for post-disaster recovery and reconstruction.

4.6.4.4 Measures to increase resilience of buildings**Definition of activity:**

- Protection from extreme temperatures
- Resistance to wind and earth movement
- Resistance to humidity and water damage
- Preparedness to power outages

Every city should have a resilient power strategy to ensure that critical public and private facilities can keep operating, the communication systems function, and emergency services remain functional if power is disrupted. Resilient power technologies such as solar plus battery storage to protect critical facilities from power outages now enable this function (NREL, 2018). Embedded microgrids, which include renewable energy distributed generation combined with energy storage, load management and smart systems, can disconnect from the main grid through “adaptive islanding” if major disruptions. These microgrid solutions are emerging as a key element of urban energy systems resilience (Ostefeld, Whitmeyer and Von Meier, 2018). Resilience strategies are also required for water supply in areas subject to drought, including water efficiency among consumers, rainwater harvesting and water reuse.

Describing sub-roadmap

1. Initiate: Develop guidelines and tools to support sustainable building design and renovation. Define suitable measure to improve buildings resilience to climate change and likely local impacts. Exchange with international scientific community and increase knowledge on specific construction measures to increase the adaptive capacity of local buildings.
2. Knowledge: Develop specific regional guidelines for architects and planners, house owners and landlords with specific requirements for buildings and built areas. Include specification to prevent urban heat islands (shading and green spaces, materials and colours), flooding impacts (drainages, water resistant materials, clustering of electric power lines), power outages (batteries and self-contained power supply) and damages from wind hazards and landslide (structural enhancement, materials, reattachment).
3. Practice/upstream: Setup regulations to establish mandatory requirements for specific risk areas. Create financing mechanisms for resilience measures. Provide funding schemes for and public (municipalities) and private buildings (house owners, landlords) to increase the overall resilience of buildings, especially in high-risk areas.

4. Mainstream/monitor: Monitor the implementation of resilience measures as described in the guidelines/regulations for new development areas as well as existing areas. Initiate enforcement schemes for mandatory requirements.

Describing the status quo of tier groups

- Early Development: N/A
- Moderate Development: Available reports expressing the status of each climate disaster that might impact the country without any detailed strategies for mitigation. The topic of resilient power is not covered.
- Advanced Development: Some guidelines are available to protect from certain climate disaster. Protection from extreme temperatures Building Code gives criteria for the design of building envelope which would be considering to the protection against high temperatures.

Resistance to wind and earth movement: Seismic Code and Wind Code , where the wind code gives the minimum loads that will be considered when designing structures for wind, including the main structural system, external façade elements, and other components that are exposed to wind, while for the Seismic Code the structural criteria for buildings to withstand any earthquakes or earth movements.

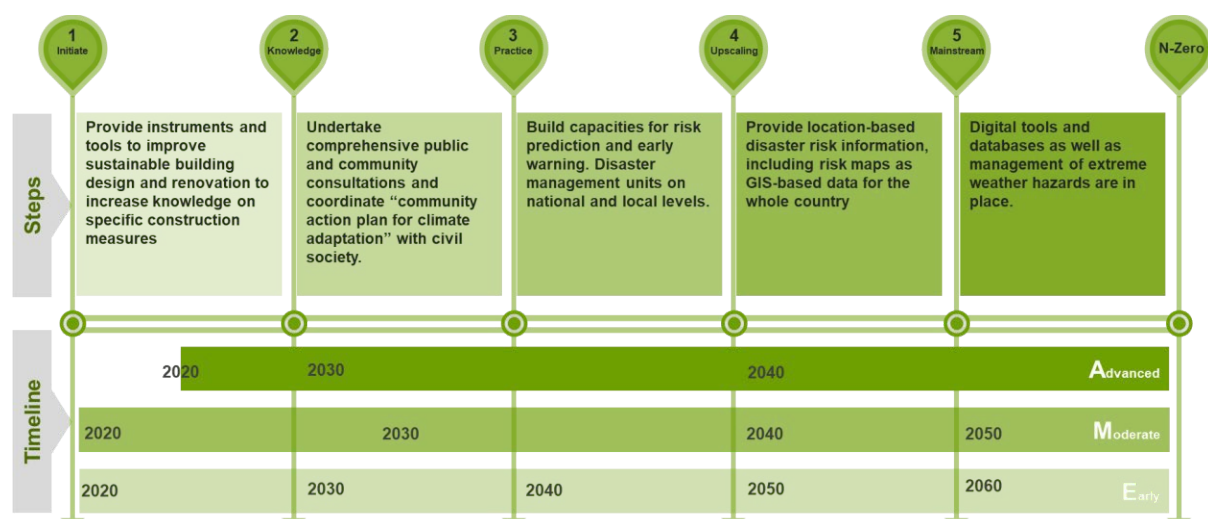
Resistance to humidity and water damage: No clear consideration of humidity and water damage is widely applied to policies, but the technology of materials having water resistance is available, e.g. plasterboards and different components provided by Gyproc

Next steps

- Early: Define locally appropriate measure to improve buildings resilience to climate change. Develop guidelines and tools to support sustainable building design and renovation. Increase knowledge on specific construction measures.
- Moderate: Define locally appropriate measure to improve buildings resilience to climate change. Develop specific regional guidelines for relevant actors. Describe specific requirements for buildings and built areas and work on regulations to establish mandatory requirements for specific risk areas.
- Advanced: Setup regulations to establish mandatory requirements for specific risk areas. Create financing mechanisms for resilience measures to support the implementation. Monitor implementation and initiate enforcement schemes for mandatory requirements.

4.6.4.5 Sub-conclusion

Figure 31 shows the main (aggregated) steps to decarbonise the technology for Activity 7. The bottom half of the figure illustrates the mapping of the three development phases and the upper half shows the recommended steps.

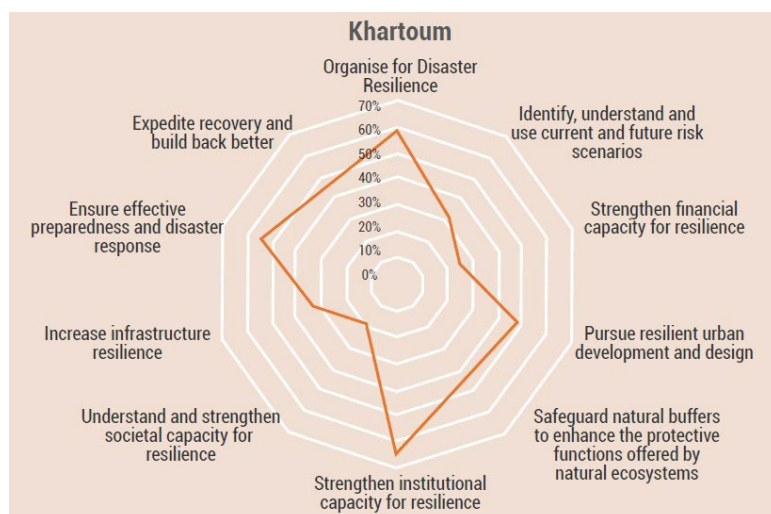


Key message: Supporting detailed targets can enable the broader sustainable development goals.

Figure 31. Roadmap for Activity 7 – resilience, technology.

4.6.5 Best practices and resources for urban resilience

Policy/Planning: Khartoum Disaster Risk Reduction Plan Development

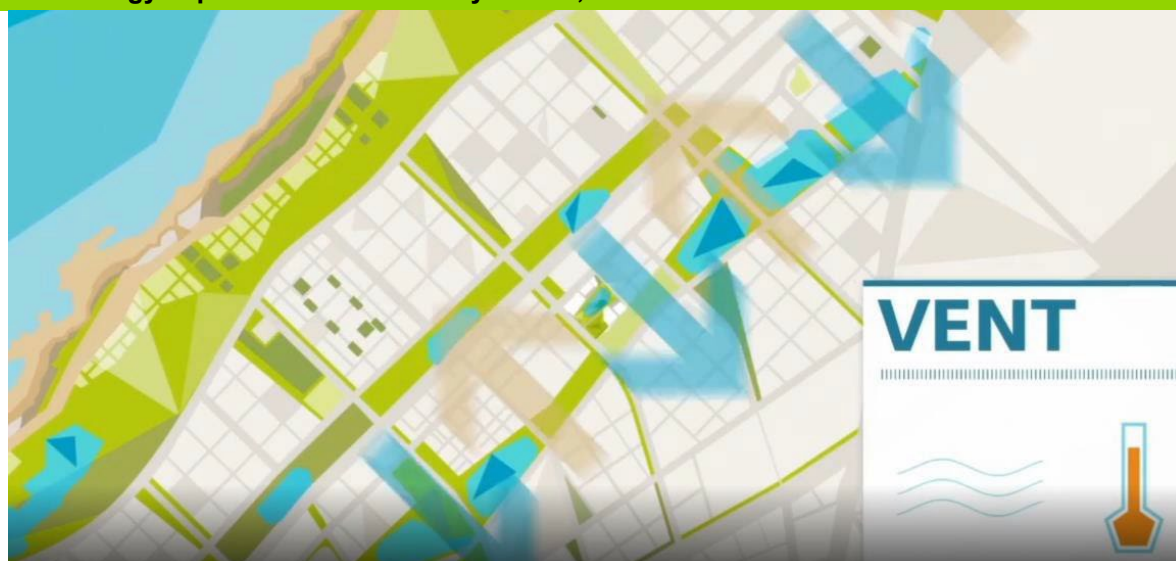


The Khartoum Disaster Risk Reduction Plan uses a methodology based on the use of UNISDR scorecard assessment, which is structured around the Sendai 10 essentials, in addition to the literature review and input from the Khartoum focal point (the Ministry of Infrastructure and Transport) for the initiative mentioned above. It has resulted in the strengthening of institutional capacity for resilience at least in some areas, especially the exposure of the public to education and awareness

materials/messaging, learning from other cities, private sector links, engagement of the insurance sector.

Sources: Khartoum Disaster Risk Reduction Action Plan (2019-2023), The Sudan, Ministry of Infrastructure and Transport and UNDRR, 2019

Technology/Implementation: Eco-City Zenata, Maroc



Source: <https://zenataecocity.ma/>

The Zenata Eco-city uses a sustainable urban design and adopts intelligent use management of natural elements. One of the highlights of the Eco-city is its integrative concept of wind channels, vegetation and retention ponds, which cools down the city during summer and drives away humidity in the winter. Another innovative feature of the Eco-city is its rainwater optimisation that avoids flooding.

4.7 Activity 8: Clean energy

Buildings are not standalone energy objects—they are deeply connected to energy grids and district energy networks. To enable 100% clean energy for buildings, onsite energy efficiency and renewable energy needs to be combined with energy network energy efficiency and renewable energy. Moreover, new energy services can be provided by buildings, such as energy storage (i.e. smart grid services and thermal storage) to enable increased resilience. The following lists three key actions for each development phase.

4.7.1 Key actions for clean energy

Key actions to enable increased clean energy in early starter countries include:

- Remove subsidies on fossil fuels to allow real competition (and comparison).
- Prepare a SMART strategy and track closely the progress.
- Empower focused institution on clean energy and establish an enabling framework.

Key actions to enable increased clean energy in moderate countries include:

- Remove subsidies on fossil fuels to allow real competition (and comparison).
- Prepare a SMART strategy and track closely the progress.
- Make the utilization of solar energy on buildings more attractive (e.g. awareness, trainings and financial incentives).

Key actions to enable increased clean energy in advanced countries include:

- Remove subsidies on fossil fuels to allow real competition (and comparison).
- Promote green power procurement, where local distributed generation is not feasible.
- Encourage more R&D and innovative solutions (e.g. promote building integrated PV, new storage solutions).

4.7.2 Stakeholders for clean energy

In the Arab region, the key stakeholders for clean energy include those that can influence the availability of clean energy technology and services and those that can deliver the results of clean energy supply to buildings. Additional stakeholders include those that can support the process through research, funding, and training. All these stakeholders are essential to delivering on roadmap targets. Table 11 shows the stakeholders; the darker the colour of the cell, the more relevant the stakeholder is. The key stakeholders are marked in bold.

Table 11. Stakeholders for clean energy.

Stakeholders	
National government	Renewable energy product providers
Subnational government	Civil society
Implementing and enforcement agencies/actors	Renewable energy service providers
Building authorities and housing associations	Researchers
Architects and engineers	Financial institutions
Property developers	Training and capacity institutions/providers
Utility companies and municipal service authorities	Business associations

4.7.3 Policy for clean energy

Clean energy policy can support low-emission, efficient, and resilient buildings goals by enabling market transformation that reduces the carbon intensity of sustainable buildings. Within the targets for clean energy, the following sub-activities offer more details:

4.7.3.1 Distributed renewable energy

Definition of activity

At the building level, onsite renewable generation is one of the possible strategies to achieve net-zero energy and net-zero carbon standards. Buildings may fully or partially meet their energy needs with local heat and electricity generation systems (solar PV, solar thermal, biogas and geothermal, among others). Local production of renewable heat and electricity to displace fossil fuel consumption offers multiple benefits, including not only lower environmental impacts (e.g. GHG emissions, particulate emissions) but also energy diversification resulting in greater energy security and lower energy dependency for import countries, and greater possibilities of local energy governance at community level. The widespread adoption of distributed energy generation can be further encouraged through feasibility studies for the installation of onsite generation projects in new and existing buildings.

Describing sub-roadmap

1. Preparatory steps: Perform feasibility studies to assess the most cost-optimal renewable energy technologies and assess the technical potential of renewable energy exploitation (e.g. Solar roof atlas). Calculate scenarios estimating the GHG mitigation depending on the RE penetration
2. Vision and strategy formulation: Draft clear goals based on the analytical work done in the preparatory steps and in accordance with the national climate and energy strategy. The goals should be formulated in a SMART manner and ideally foresee the complete time period till net-zero (long term), but minimum 5 or 10 years. To meet the goals, instruments should be designed to ensure the success, depending on the macroeconomic situation different measures can be used, like pull factors (financial incentives) or push factors (regulation) in every case a good awareness strategy needs to be developed.
3. Instruments: For the example of solar thermal collectors – solar thermal decrees have been proven as functional (see Chapter 0). Another instrument could be to offer financial incentives, the Tunisian experience with the programme called PROSOL has shown as well that the penetration rate of solar thermal collector has increased significantly with the support that has been offered. Certainly, there are other instruments that can lead to a higher RE share, their selection needs to fit to country (regional) context. This step should be accompanied by capacity building activities.
4. Monitoring and reporting: Develop a yearly monitoring procedure to track the progress of the implementation (e.g. the installation of solar thermal collectors). Depending on the selected instrument matching, consider measurement, reporting, and verification indicators.
5. Evaluation: An evaluation round should be incorporated after the monitoring results to finetune or even withdraw the installed instrument(s). This should be planned in as well on a regular basis and will allow the successful meeting of the targets.

Describing the status quo of tier groups

- Early Development: Electricity is produced based on hydro, in addition there are some ground-based PV systems. For remote areas solar mini grids are being promoted.
- Moderate Development: The expansion of the use of renewable energy in general is apparent on large-scale applications. On the buildings level, the net metering scheme of solar power is introduced allowing small-scale RE installations in the residential, industrial, and commercial sectors. yet, a limited number of buildings implemented this.
- Advanced Development: Renewable energy is part of the guidelines for green buildings' requirements as it aims to reinforce the use of renewable energy to reduce dependence on electricity generated on the grid using conventional technologies. The requirement can be met by:
 - Option 1: Installing PV panels or solar thermal collectors. Install photovoltaic panels and/or solar thermal collectors on an area equivalent to at least 25% of the site area (including the building footprint). The panels can be rooftop mounted, ground mounted, or part of any shade structures. The PV system(s) should be connected to the building.
 - Option 2: Providing solar ready spaces. At least 25% of the site area (including the building footprint) should be solar ready. This can be for panels that will be rooftop mounted, ground mounted, or part of any shade structures.
 - Option 3: A combination of Option 1 and 2. At least 25% of the site area (including the building footprint) should be solar ready or have photovoltaic panels.

Next steps

- Early: The first two steps have been already concluded, scenarios and target settings. Step three needs more attention or step 2 (target setting) needs to be re-evaluated as the initial set targets are falling behind with nowadays reality.
- Moderate: Reiterate step 2: target setting, draft SMART targets and track the progress closely. This is crucial as the set targets (20% RE share by 2022 S: 2016_IRENA_RE Arab Region Overview of Developments) seems to be difficult to achieve, as latest IRENA statistics of 2020 state a share of 10% RE.
- Advanced: Focus on step 3 and create further an enabling framework to boost the penetration of renewable energies. Besides the existing push instruments (e.g. regulation), offer as well pull instruments (funds or other) to make sure that the formulated targets will be met.

4.7.3.2 Building codes

Definition of activity

The incorporation of measures such as readiness for demand-side response measures, obligations for renewable energy systems or provisions for their future installation (e.g. structural integrity requirements) can be stipulated in building codes. The codes should be developed jointly among national authorities, builders and other stakeholders so appropriate technologies are considered and mandatory requirements are applicable, enforceable, and well-designed. Building codes also must include requirements in structural integrity or other requirements which will enable the safe inclusion of onsite renewable energy systems.

Describing sub-roadmap

1. Preparatory steps: A clear overview of existing instruments and stakeholders that promote renewable energy needs to be available to avoid any confusion or doublings. The relevant authority for the development of building codes needs to be closely supported while integrating technical details of renewable energy systems in the building code.
2. Integration of renewable energy technology into the building code: Based on analytical studies (e.g. feasibility studies, cost-optimal analysis, pilot projects etc.) a range of RE solutions should be provided allowing the engineers and architects freedom to select the most suitable technology for their specific project. The RE technology should be clearly defined (incl. their size / share and their use case). A special attention should be given to any possible contradiction with other renewable energy technologies and other existing definition of HVAC technologies.
3. Review and testing with expert group: The formulated definitions of renewable energy technologies should be reviewed by an external (outside the building code resp. entity) expert group and possible gaps should be pointed out.
4. Evaluation: The responsible building code entity reviews the received feedback and corrects the identified gaps.
5. Final integration: The final definitions of the renewable energy technologies should be integrated in the building code incl. possible calculation tools and training curricula. Furthermore, all relevant stakeholders should be informed about the new changes and accordingly trained.

Describing the status quo of tier groups

- Early Development: N/A
- Moderate Development: A renewable energy law is established with the following steps in place:
 - Establish the NREA. The NREA has the primary role in promoting and developing renewable energy. To gain optimum benefits from renewable energy,
 - Promote its investments and encourage R&D, in addition to local manufacturing.
 - Support the creation of a favourable economic environment for a significant increase in renewable energy investment in the country.
 - Establishes the basis for the feed-in tariff (FIT) for electricity produced from renewable energy projects and encourages investment in renewable energy.
 - Regulates to avail land for renewable energy projects.
 - Provide legislative and regulatory frameworks needed to achieve the electricity market reform targets.
 - Ensures investment guarantees.
 - Establishes a new arbitration centre for settling disputes.
 - Codifies social responsibility.
 - Promotes foreign investment.

- **Advanced Development:** Building codes includes information on stationary fuel cell power systems. Such systems shall be tested according to ANSI/CSA FC 1 and installed in accordance with the manufacturer's installation instructions and NFPA 853. Also, part of the renewable energy requirement for green building guidelines , at least 25% of the site area (including the building footprint) should be solar ready. This can be for panels that will be rooftop mounted, ground mounted, or part of any shade structures.

Next steps

- **Early:** As energy efficient building codes are partly not available in many cases, consider integrating the most effective renewable technologies in the first code draft (e.g. solar thermal collectors or PV). Provide a minimum share of onsite renewable energy supply for new buildings.
- **Moderate:** Start to integrate a minimum of renewable shares in energy efficient building codes. The integration should start with new buildings and reasonable share of cost-effective renewables (based on the countries realities). It makes sense to offer by-passes that still lead to an overall reduction of the energy consumption (e.g. better building envelope or higher efficient HVAC) if the integration of renewables is not possible.
- **Advanced:** Increase the already asked share of renewables to reach zero energy buildings by 2030, starting with new buildings and followed then by retrofits.

4.7.3.3 Regulatory framework

Definition of activity

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

Describing sub-roadmap

1. **Preparatory steps:** Establish specialised institutions to promote renewable energies. This entity should perform several preparatory tasks like the development of scenarios, the elaboration of feasibility studies and the analysis of best practices.
2. **Strategy and conception:** The planned regulatory framework should be in line with the overall strategies relevant to the specific renewable energy source.
3. **Instruments:** Several instruments are needed to establish a “robust functioning” regulatory framework:

Firstly, draft laws and decrees that regulate the technical integration into the grid composed of a grid code formulated by the regulator or utility. It needs to define transparently the access of the grid and clearly clarifies the grid connect charges (who pays the bill?). Furthermore, it needs to respond to the technical questions like grid capacity.

Secondly, to attract the uptake of e.g. roof-based photovoltaics the conception of an encouraging environment is essential. Different options can be referred to like: Feed-in tariff, PPA's or Net metering (not exclusive). In below some of the major provisions of net metering are presented (S. 2019, Gov of India, report on metering regulation and

accounting framework for grid connected rooftop solar PV in India). In the following major provisions to promote net metering are presented:

- a. Applicability
- b. Business models
- c. Metering
- d. System capacity
- e. Limits on system loading
- f. Communication capability
- g. Rate applicable if exported to the grid

Another element that needs clarification are permits, which need to be as well refer to other existing norms and regulations (building codes) covering i.e. simplified environmental safeguards and the safety aspects (wind loads or fire)

4. Monitoring and reporting: Make sure to plan in smart indicators that can be regular tracked, to ensure a successful rollout of the regulatory framework
5. Evaluation: An evaluation round should be incorporated after the monitoring results to finetune or even withdraw the installed instrument(s). This should be planned in as well on a regular basis and will allow the successful meeting of the targets.

Describing the status quo of tier groups

- Early Development: N/A
- Moderate: The adaptation of renewable energy strategy is established, includes all or part of the below:
 - Sustainable Development Strategy Development, ensuring:
 - Goal I – Ensuring security of supply
 - Goal II – Ensuring sustainability
 - Goal III – Improving institutional and corporate governance
 - Goal IV – Strengthening competitive markets and regulation
 - Regulatory framework:
 - Establishment of renewable energy development and usage authority.
 - Promoting for renewable energy and encouraging R&D as well as local manufacturing.
 - Renewable Energy Law aiming to create a favourable economic environment for investment.
- Advanced Development: Governing body tasked with strategic policy and regulation decisions are established. Subsidies reforming by raising the electricity and water tariffs is taken. Few initiatives of implementing an auction mechanism that follows IPP-PPA model, totally away from EPC are on-going allowing the private sector to be included..

Next steps:

- Early: Install specialised institutions to promote renewable energies and enable the entity to perform all necessary preparatory tasks as illustrated in the sub-roadmap.

- Moderate: Monitor and track the progress of the available framework are implemented instruments. Reiterate if lacking positive progress
- Advanced: Monitor and track the progress of the available framework are implemented instruments. Reiterate if lacking positive progress

4.7.3.4 Reforming fossil fuel subsidies

Definition of activity

The environmental and health costs of fossil fuel usage must be accounted for when comparing the costs of fossil fuels to those of renewable energy sources. This would mean phasing out fossil fuel subsidies and setting appropriate taxation wherever applicable. Rolling back subsidies may be complemented with more targeted social welfare measures, to mitigate the socio-economic impacts on the population, in particularly the most vulnerable. For example, in developing Asia, 9 subsidies for kerosene, generally used for lighting, cost USD 10.2 billion per year (Evan, 2017). Subsidy reforms could enable replacements such as solar lighting distribution instead. Similarly, incentives can be used to promote renewable energy. These incentives can be non-financial, like expedited product approvals and permits, or financial. The former offers appropriate enabling conditions for the development of renewable energy technology, while the latter can substantially accelerate its deployment by encouraging private investment.

A variety of organisations have studied how to best achieve subsidy reform, and they conclude there is no one-size-fits-all solution to reform. However, there are common elements for successful reform. The International Monetary Fund (IMF) outlines six key elements:

Describing sub-roadmap

1. Clear long-term objectives – as part of a comprehensive reform plan, which could include objectives such as achieving full price liberalization and improving the quality of service.
2. Communication strategies – must be well planned and timed and reach all audience groups. Consultation with stakeholders is also an important element.
3. Timing and phasing - appropriately phased and sequenced price increases, which give households and businesses time to adjust their energy consumption.
4. Mitigation measures – to fairly compensate groups that lose out from reforms.
5. Improved efficiency of public finance and enterprise - improvements in the efficiency of state-owned enterprises help to reduce their fiscal burden.
6. Depoliticised energy prices - price setting should be made as independent as possible from politics to ensure durable reforms.

Describing the status quo of tier groups

- Early Development: Government increased prices for electricity as part of an ongoing economic reforms package, reduced subsidies on , but maintained higher subsidy rates for lower consumption tiers.
- Moderate Development: Government reformed fossil fuel subsidies, raising the price of widely consumed petroleum products, so the reforms aimed to help close a budget deficit. Increasing the electricity tariffs incrementally as part of the plan to remove energy subsidies totally.

- **Advanced Development:** Several energy prices is increased, furthermore, petrol and gasoline prices have been increased. Also, Electricity prices is increased with a slab tariff is being implemented with progressively, price increases with the increase of electricity consumption.

Next steps

- **All:** It is difficult to differentiate the tier groups in this sub-activity, as it is per se not related to the development phase, but strongly depending on country-specific factors. Obviously net importers have a higher need to eliminate subsidies on fossil fuels than exporting countries. Nevertheless, to promote energy efficiency and renewable energy each Arab country should reduce subsidies on fossil fuels in short-term. It is important that the shift conceived socially fair and transparent.

4.7.3.5 Sub-conclusion

Figure 32 shows the main (aggregated) steps to decarbonise policy for Activity 8. The bottom half of the figure illustrates the mapping of the three development phases and the upper half shows the recommended steps.

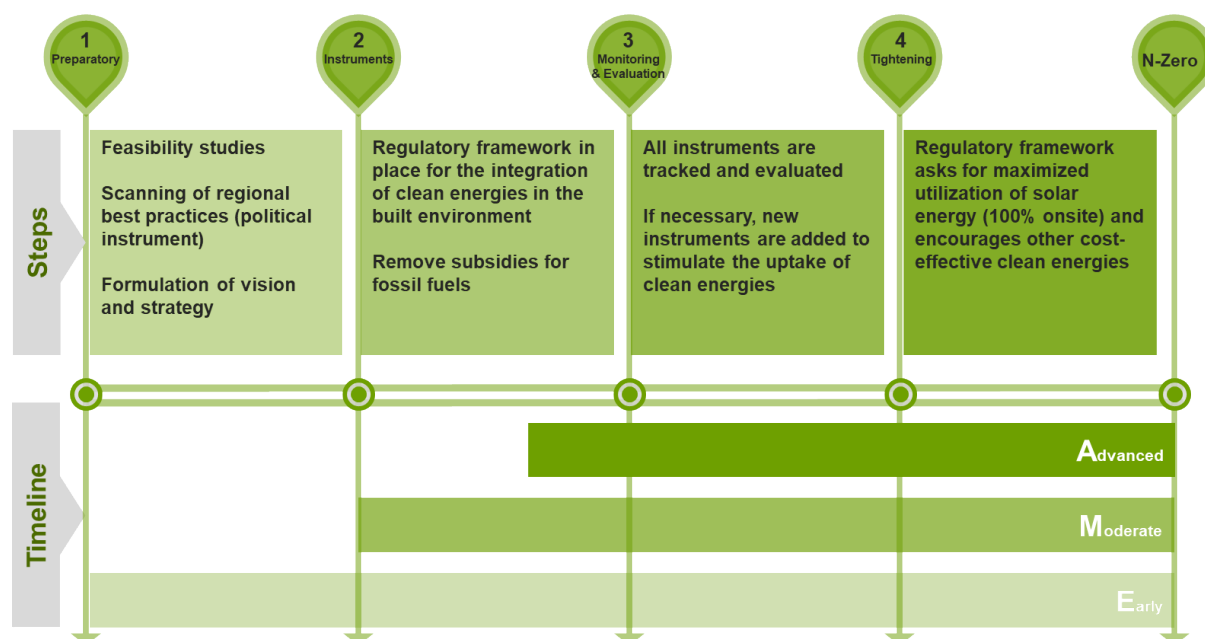


Figure 32. Roadmap for Activity 8 – clean energy, policy.

4.7.4 Technology for clean energy

The lifecycle energy and emissions for buildings are influenced by the energy used in buildings. Specific sub-activities for clean energy are outlined below:

4.7.4.1 Solar thermal

Definition of activity

Onsite solar thermal collectors produce hot water in a renewable way and should be encouraged in areas of high solar radiation. Solar thermal systems have significant potential to displace electricity consumption from electric residential hot water production at a competitive price.

Describing sub-roadmap

1. Preparatory steps: Understand your market realities by performing a market analysis / baseline study. After that, conduct feasibility studies for typical reference buildings, like single-family houses, multifamily houses and hotels or other non-residential buildings with a high hot water demand. Put a special focus also on the economic performance and investigate the barriers. Then conduct a regional best practices study, here could refer the experiences gained in Palestine, Tunisia, and other countries in the region with a high penetration of solar thermal collectors.
2. Strategy and conception: Draft a SMART vision to increase the penetration of solar thermal collectors. As an orientation a possible target value could be around 400 m²/1000 inhabitants, which is in the range of current top performing country - Palestine (2021_IEA SHC_Solar-Heat-Worldwide). Exact targets need to be formulated on country basis.
3. Instruments: Apply a mixture of instruments suitable to the specific country environment: awareness raising, capacity building, regulation, certification and if macroeconomic situation allows consider the development of funds to scale up the use of SWH.
4. Monitoring and reporting: Install monitoring procedures to track the development of the technology deployment.
5. Evaluation: Check on regular basis (e.g. yearly) the development and verify the selected instruments.

Describing the status quo of tier groups

- Early Development: N/A
- Moderate Development: The use of SWHs is mandatory in new cities. Reducing the subsidised energy prices, and spreading awareness should go in parallel to support this decision.
- Advanced Development: The installation of Solar Water Heaters in all construction is required to provide a minimum of 75% of domestic hot water requirements.

Next steps

- Early: Understand your market realities by performing a market analysis and a gap analysis comparing your country's situation with best performing from the region or other international examples. Based on the findings and other preparative studies a strategy needs to be outlined.
- Moderate: Introduce cost attractive funding programmes to promote a higher use of solar collectors, this should be coupled with high-quality standards, awareness rising and training programmes.
- Advanced: Monitor and track the progress, reiterate if not matching results.

4.7.4.2 Solar PV

Definition of activity

Onsite building integrated or roof-mounted PV can enable the generation of electricity for self-consumption. According to the size of the installed system, buildings could partially or totally cover their electricity needs on an annual basis. Coupling with battery energy storage systems (BESS) can provide off-grid buildings with the required flexibility to meet their electricity demand at times of no generation (e.g. at night). Surpluses can also be delivered to the power

grid using bidirectional metering. Low-voltage direct current home solar systems also offer significant potential for increasing access to electricity.

Describing sub-roadmap

1. Preparatory steps: Perform a baseline study to understand the status quo of photovoltaics in your country. After that, conduct feasibility studies for typical installation cases differentiating between residential and non-residential buildings, put a special focus on the share of self-consumption (with and without battery backed up systems) and estimate the economic performance. In the next step, conduct a gap analysis, including the investigation of barriers (regulative, technical and financial), the elaboration of regional best practices and showing off how the gaps can be closed. The recommendations should support the upcoming steps (strategy formulation and instruments definition).
2. Strategy and conception: Draft a SMART vision that targets an increased use of onsite PV. Ambitious targets can be already found in countries of the region, see also the programme: Shams Dubai which is planning to have every roof equipped with PV by 2030 (2021_Mesia_MENA Solar and RE Report). This step should be accompanied by capacity building activities.
3. Instruments: There is no silver bullet to scale up the use of PV, therefore apply a mixture of the arsenal of instruments suitable to the specific country environment: Led by awareness raising, capacity building, regulation, certification and if macroeconomic situation allows – funds e.g. in the context of roof-based PV most common offerings are in the form of net metering or FIT.
4. Monitoring and reporting: Install a monitoring procedure to track the development of the technology deployment with clear indicators and allocation of stakeholders.
5. Evaluation: Check on regular basis (e.g. yearly) the development of the technology and verify the effectiveness of instruments used.

Describing the status quo of tier groups

- Early Development: Initiation of drafting renewable energy laws and policies for private investments promotion that include the possibility for FIT, with a focus on small-scale distributed generation to improve the energy accessibility. Initiatives to utilize solar in some villages, enhancing health clinics and schools, street lighting and solar water pumping.

Moderate Development: Installation of on-grid distributed PV systems started through government initiatives for rooftop PV systems on public buildings. PV projects for electrification of remote villages is established, some centralised systems and hybrid PV-diesel systems projects are initiated, with several initiatives for small-scale PV have been introduced. Distributed solar PV technologies are developing.

- Advanced Development: Government initiative that encourages household and building owners to install PV panels to generate electricity is launched, and home owners with solar panels system installed in their homes is growing.

Next steps

- Early: Understand your market realities by performing a market analysis and conduct a gap analysis comparing your country's situation with best performing from the region or other international examples. Based on the findings and other preparative studies a strategy needs to be outlined.

- Moderate: Introduce cost attractive funding programmes to promote a higher utilization use of roof-based PV, this should be accompanied by high-quality standards, awareness rising and training programmes.
- Advanced: The Shams Dubai program outlines already the ambitious target that every roof should be equipped with PV by 2030. If this can be achieved in the period of time, this technology pathway would be fully on track.

4.7.4.3 Geothermal heating or cooling

Definition of activity

Geothermal systems exploit the Earth or bodies of water as a heat sink or source, to provide heating or cooling. They can be used in combination with a heat pump, or where temperatures allow, in a direct circulation loop. Policy support in the form of risk guarantees or investment grants can help mitigate investment risks associated with high upfront costs and uncertain drilling operation outcomes.

Describing sub-roadmap

1. Demonstration: The first step includes the installation of pilot project(s) to prove the technical feasibility of the technology. These pilots should be fully monitored and analysed allowing the formulation of improvements to prepare for the next phase. This step is fully subsidised by R&D-related grants.
2. Pre-commercial: The second step should be built on the learnings of the first phase and allow a (smaller) replication of the pilots, testing them in other locations and improve them while harvesting from the first learnings. It's recommended to seek for an engagement of the private sector and to jointly perform the installation of the next round of pilots. This could allow the future evolvement of spin outs and allow the reduction of investment risks. This could allow the future evolvement of spin outs and allow the sequential reduction of investment risks.
3. Supported commercial: The third step is the stage where, given renewables support the roll- out in substantial number and by commercially oriented companies.
4. Mainstream: In the last step the technologies can compete unsupported in the market and are becoming mainstream.

Describing the status quo of tier groups

- Early Development: N/A
- Moderate Development: Still the geothermal heating or cooling is not applicable.
- Advanced Development: Limited number of geothermal wells are used to explore and study how geothermal energy could be used for cooling purposes. and the viability to use geothermal energy technology for cooling and the possibility to substantially reduce electricity consumption.

Next steps

- Early and Moderate: Install pilot project(s) to prove the technical feasibility of the technology. This pilot should be fully monitored and analysed allowing the formulation of improvements to prepare for the next phase.

- Advanced: Analyse the learnings of the pilot project and allow a (smaller) replication, testing them in other locations and improve the overall efficiency of the system.

4.7.4.4 Energy storage

Definition of activity

With increasing shares of variable and non-pilotable renewable energy in the energy supply, energy storage (TES) becomes an important element for balancing supply with demand. Thermal energy storage can be implemented at the building or district scale, with higher cost-effectiveness at the latter. Coupled with solar thermal systems, heat storage tanks can ensure continued supply of hot water. Coupled with electric boilers or heat pumps, heat, chilled water or ice storage make it possible to avoid curtailment during periods of excess electricity production from variable renewable sources, and shift load to off-peak hours to lower the strain on the grid. Battery energy storage systems (BESS) can store electricity for delayed uses, providing flexibility to off-grid buildings equipped with distributed variable renewable energy technologies, such as distributed PV. Time of use (ToU) tariffs for electricity can incentivise the deployment of behind-the-meter BESS in connected buildings, as these BESS allow consumers to reduce grid-electricity consumption at peak hours and even potentially to sell electric surpluses to the grid, using bidirectional metering at the most profitable time. However, unless all BESS include bidirectional metering, on-grid storage offers a more economical and energy efficient solution than behind-the-meter storage from a system perspective, due to (i) economies of scale (ii) the smoothening effect from both demand and supply aggregation, which reduces the overall storage capacity needs, and the intensity of its use.

Describing sub-roadmap

1. Preparatory steps: Feasibility study of thermal versus BESS plus concentrated solar power (CSP) (thermal solution) lost attraction in the last year, while BESS solutions with PV gained interest. Nevertheless, lifecycle aspects need to be as well taken into considerations and possible material shortages. Both solutions could be followed complementary incl. battery for small- and large-scale solutions. In the following a possible pathway for large-scale BESS is illustrated
2. Demonstration and pre-commercial: The first step includes the installation of pilot project(s) to prove the technical feasibility of the technology. A possible higher economic return is estimated in remote areas or areas with non-stable electricity-supply; therefore, these sites should be prioritised. These pilots should be fully monitored and analysed allowing the formulation of improvements to prepare for the next phase. This step could be fully subsidised by R&D related grants or cross financed by stakeholders of the private sector. This “buy.in” would allow in future the evolvement of spin outs and allow the sequential reduction of investment risks.
3. Supported commercially: The third step is the stage where incentives are given to support the roll- out in substantial number by commercially oriented companies.
4. Mainstream: In the last step the technologies can compete unsupported in the market and are becoming mainstream.

Describing the status quo of tier groups

- Early Development: N/A
- Moderate Development: Still the energy storage is not applied in the buildings sector.

- **Advanced Development: BESS:** A pilot project is implemented on a large scale from TESLA, creating battery energy storage system attached to a solar farm. This proves that the technology is available but the application within the buildings sector is not applied.

Testing of NaS battery storage system to help stabilise renewable energy outputs is on-going.

For the Arab region the following CSP plants were researched:

Table 12. CSP plants in the Arab region in 2020 (2021_IRENA_Renewable Energy Statistics).

CSP in MW (2020)	
Algeria	25
Egypt	21
Morocco	540
Kuwait	50
Saudi Arabia	50
UAE	100

Next steps

- **Early:** Conduct feasibility studies to assess the attractiveness and the potential of energy storage solutions in your country
- **Moderate:** Conduct feasibility studies to assess the attractiveness and the potential of energy storage solutions in your country. Then, test pilot application(s) and monitor the performance.
- **Advanced:** Draft a financial framework to allow the rollout in a substantial number of commercially oriented companies.

4.7.4.5 Sub-conclusion

Figure 33 summarizes the main (aggregated) steps to decarbonise the technology for Activity 8. The bottom half of the figure illustrates the mapping of the three development phases and the upper half shows the recommended steps.

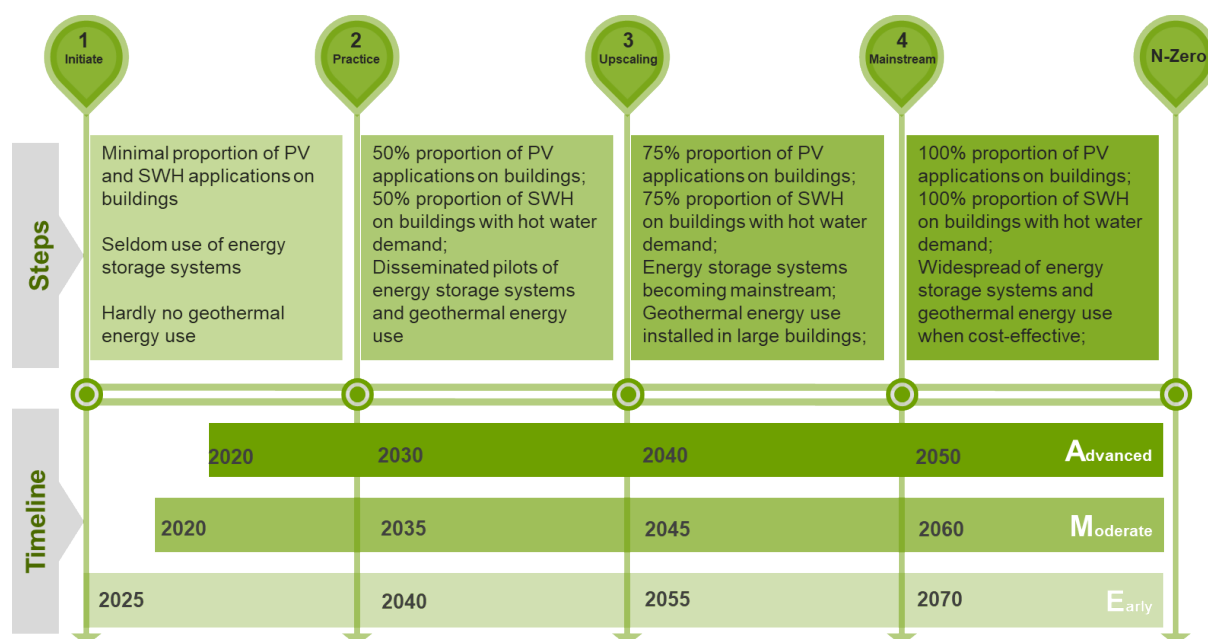


Figure 33. Roadmap for Activity 8 – clean energy, technology

4.7.5 Best practices and resources for clean energy

Policy/Planning: Solar Thermal Ordinance, Barcelona, Spain



The city of Barcelona, Spain, became the first city in Europe to pass a solar thermal ordinance, in 2000. It requires that 60% of running hot water be covered through solar thermal energy in all new or renovated buildings and in buildings whose primary purpose has been altered. The city has made notable efforts to familiarise residents with this technology and to address initial performance problems. The “Solar Reflection Days” initiative showcased state-of-the-art solar thermal systems. “Taula Solar”, a stakeholder forum, was formed to discuss the objectives and scope of the ordinance with architects, engineers, residential building administrators, a consumer association, solar industry representatives and others.

Source: 2021, IRENA – RE Policies for cities

Technology/Implementation: CIB Bank Development



The building of the CIB bank in Egypt integrates solar energy plant building integrated PV in the building envelope, thereby, replacing conventional building material. The architectural design combines aesthetics with additional features such as structural functionality through waterproofing, safety and sun protection with the added value of electricity generation and delivering energy efficiency through a low-carbon approach.

Source :<http://summitegy.com/projects/cib-bank-smart-village/>

5. Enablers, crucial instruments to boost decarbonisation

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

5.1 Finance

Finance can enable increased action toward low-emission, efficient and resilient new buildings. Specific finance sub-targets and timelines are outlined below:

5.1.1 Urban development funds

Definition of activity

Dedicated funding for urban development projects, which can be directed toward sustainable urban development projects.

Describing the status quo of tier groups

- Early Development: No urban development funds are in place.
- Moderate Development: No governmental programmes to finance sustainable urban development projects. Several initiatives and programmes are being implemented to support and fund sustainable urban development projects.
- Advanced Development: Sustainable Finance Framework is developed. The funding is directed in the following channels: embedding sustainability in the existing policies, management of climate-related risks, develop environment stress testing tools, and proposing guidance on ESG- and climate-related reporting and disclosure. No specific funding in the direction of urban development.

Case Study**Sustainable Urban Demonstration Projects (SUDEP) South Support Mechanism**

Funded by the European Commission, the Sustainable Urban Demonstration Projects (SUDEP) was developed to offer demand driven technical assistance to municipalities across the MENA Region (SUDEP, 2019). SUDEP was able to provide:

- Supporting the municipalities to create their own methodology to develop and implement sustainable urban development projects
- Supported several municipalities to prepare bankable projects which helped them to secure finance from third parties.
- Supporting in the process of joining to the Covenant of Mayors. Support the preparation of sustainable energy and climate action plans required to join the Covenant.

Example of projects supported by SUDEP

Improving the capacities of local authorities to develop and implement sustainable energy efficiency practices and renewable demonstration actions in Tubas, Jerusalem. The project supported the implementing of different measures such as:

- Implementation of six net metering PV systems in the significant public buildings.
 - Design and development of an innovative WEB Platform to monitor and control the energy consumptions of each of these buildings.
 - Planning and implementation of training and social awareness campaigns (SUDEP, 2019).
-

5.1.2 Infrastructure funds**Definition of activity**

Dedicated funding for infrastructure projects, which can be directed toward sustainable infrastructure projects.

Describing the status quo of tier groups

- Early Development: N/A
- Moderate Development: Based on the website of Asian Infrastructure Investment Bank, Issued in Oct. 2021 Development's essential infrastructure needs can be met by increasing investments in both public and private sectors, and banks will play an important role in allowing funding where it is most needed.
- Advanced Development: Green fund is dedicated as part of the national green energy strategy. It aims to provide more energy from clean energy sources making the cities with the smaller carbon footprint.

Case Study

Dubai Green Fund DGF

DGF is aligned with Dubai's vision of sustainability. DGF underpins supports Dubai's Clean Energy Strategy 2050. DGF is an impact investor supported by the Government of Dubai and sponsored by the Dubai Electricity & Water Authority – DEWA. It the first specialised green investment fund in MENA region (Dubai Green Fund, 2022). DGF aims to:

- Encourage investment in green and sustainable projects.
- Establish a sustainable energy model that supports economic growth in an environmentally friendly manner.

DGF focused on investment in companies and projects covering a wide range of sectors including clean energy, energy & water efficiency, water & waste management, green transportation & logistics.

Example of projects supported by DGF

Mohammed bin Rashid al Maktoum solar park - phase 4

- With a total area of 44 square kilometers, and lowest levelized cost of electricity (LCOE) of USD 7.3 cents per kilowatt-hour (kWh) for the 700 MW CSP and USD 2.4 cents per kWh for the 250 MW photovoltaic solar panels.
- The project has a planned total capacity of 5,000 MW by 2030 with total investment of AED50 Billion.

Case Study

EBRD Green Cities

To address the challenges of insufficient infrastructure investments, poor air quality, energy and carbon intensities in the cities of EBRC countries, the EBRD developed EBRD Green Cities programme to provide mainly three key components as follows (EBRD Green Cities, 2022):

- Green City Action Plans (GCAPs): To assess environmental challenges and to develop an action plan addressing these challenges through policy and sustainable infrastructure investments.
- Sustainable infrastructure investment: to facilitating and to stimulate public or private green investments in infrastructure of cities. This, for example, includes investment in water and wastewater, urban transport, district energy, energy efficiency in buildings.
- Capacity building: Providing technical support to city staff and local stakeholders to ensure that infrastructure investments can be developed, implemented and monitored effectively.

Example of projects supported by EBRD Green Cities

At the time of writing this report (March 2022) four cities in the Arab countries have joined EBRD Green Cities including 6th of October City, Cairo, Alexandria in Egypt and Amman in Jordan. Some projects under the EBRD Green Cities programme have been announced. For example:

- Alexandria is committed to prepare GCAP. The plan is supported by the Government of Austria. EBRD to extend EUR 250 million loan to finance the first high-capacity metro line in Alexandria and to upgrade and electrification of an existing rail line (Zgheib, 2022).
- Amman aims through its GCAP to plan and invest in green development by addressing key challenges of solid waste management, reducing pollution and energy consumption. GAM Lagoon Remediation Project is remedial infrastructure of a water tunnelling system to drain contaminated lagoon in the city of Russeifa

(15 km northeast of Amman), to restore the original stormwater flow from Marka into Zarqa river.

5.1.3 Dedicated credit lines

Definition of activity

Funding delivered through banks for a specific purpose, such as sustainable buildings or development projects.

Describing the status quo of tier groups

- Early Development: N/A
- Moderate Development: Available of few projects funded by green loan. The Green loan allows clients to purchase solar energy systems that allows them to efficiently reduce their electricity bill, while preserving the environment.
- Advanced Development: Financial entities have signed up to the Task Force on Climate-related Financial Disclosures (TCFD) or announced the green home loans offering an interest rate discount for properties that meet certain sustainable criteria and a discount on arrangement fees.

5.1.4 Risk-sharing loan/loan guarantee

Definition of activity

Large organisation, such as a government, international bank or aid organisation, covering the risk of payment default to allow banks to fund a project with lower costs and better loan terms.

Describing the status quo of tier groups

- Early Development: N/A
- Moderate Development: Based on Stakeholder Report Development IKI Project: Accelerating 0-emission buildings sector ambitions in the MENA region (BUILD_ME), issued Feb. 2020, EBRD initiated in 2016 a new credit line for some countries known as Green Economy Financing facility (GEFF). International Finance Corporation (IFC) which is the private sector lending arm of The World Bank Group, provides loans to increase the access to finance for SME and promote sustainable energy financing and increase climate-related investment. It is in process of launching credit lines to banks to target the residential sector (Davis 2020).
- Advanced Development: According to RISE Regulatory Indicators for Sustainable Energy by World Bank, risk-sharing loan and loan guarantees are not applicable in some advanced development countries.

5.1.5 Green bonds

Definition of activity

Bonds that can be used to bundle funding associated with sustainable projects.

Describing the status quo of tier groups

- Early Development: No green bonds are in place

- **Moderate Development:** Availability of finance institutes issuing the private sector green bond. An emerging type of fixed-income security, green bonds generate capital for development projects with environmental benefits.
- **Advanced Development:** The system of green bonds is applicable in advanced development countries. The financial institutions publish reports include the framework impact reporting, the framework of green bonds, and the process of evaluation and selection and the reporting and external verification.

5.1.6 Preferential tax

Definition of activity

Direct funding from the government to reduce or eliminate the tax for sustainable products and services.

Describing the status quo of tier groups

- **Early Development:** N/A
- **Moderate Development:** The government put in place laws and regulations aim at attracting new investments through increasing the chances in restoring confidence in country's investment climate, offering further incentives and guarantees, removing obstacles, streamlining the procedure taking into consideration the existing impediments for foreign and domestic investment. As examples: trimming tax and custom duties, exclusions from bids and tender laws, and alternative forums for investor state dispute.
- **Advanced Development:** According to RISE Regulatory Indicators for Sustainable Energy by World Bank, preferential taxes are not applicable in some of the advanced development countries.

Case Study

Sales tax and customs exemptions in Jordan

Jordan has implemented a set of regulations and policy instruments which gives tax reductions and tax exemptions for energy efficient products and renewable energy applications (IRENA, 2021).

Example of tax exemptions in Jordan

- Electric vehicles were exempted from clearance taxes on import for five years until the end of 2018. In November 2019, the regulations have been updated, the incentives are now based on the battery capacity of the electric vehicles.
- The special tax on natural gas for industries has been reduced from 16% to 7%, and the companies that switch to natural gas are exempted from the special tax imposed on natural gas for three years, according to criteria set by the Ministry of Industry (NEPCO, 2019c).
- Bylaw No. 10 of 2013, amended in 2015, 2017 and 2018, allows for tax exemptions for renewable energy and energy efficiency systems and equipment. The bylaw includes a list of imported and locally manufactured equipment.

5.1.7 Grants and rebates

Definition of activity

Direct funding provided by the government, organisation or programme during or after the purchase of a sustainable product or service.

Describing the status quo of tier groups

- Early Development: There is no grants for sustainable development.
- Moderate Development: GEFF initiated by EBRD, helps the businesses invest in high-performing technologies by providing financing through local participating financial institutions.
- Advanced Development: According to RISE Regulatory Indicators for Sustainable Energy by World Bank, grants and rebates are not applicable in some of the advanced development countries.

5.1.8 Energy performance and energy service contracts

Definition of activity

Contracts for services or delivered savings that typically are delivered by an ESCO and can include a range of energy efficiency services and products.

Describing the status quo of tier groups

- Early Development: No energy performance or energy service contracts are being implemented.
- Moderate Development: International Consulting Group, work with the aim to check the possibilities and the options to improve the market status of providing energy efficiency services with focus on developing of Super ESCOs entities. It included checking the feasibility and introducing the advanced energy efficient service market. This was through assessing the structural potentials and economic feasibilities in addition to analysing the current and the future aspects related to the initiation of Super ESCOs.
- Advanced Development: Mature ESCOs market with variety of application of ESCOs services.

5.1.9 Procurement purchase and lease:

Definition of activity

The purchase or lease of sustainable products and services. Leasing enables the ability to use energy efficient products on a rental basis to reduce a capital expenditure.

Describing the status quo of tier groups

- Early Development: No policies for green procurement.
- Moderate Development: On-going development of set of recommendations and methodologies to promote sustainable public procurement. Development of new law of public procurement, and clear collaboration of stakeholders to work on feeding the sustainability aspects.
- Advanced Development: Availability of platforms allow suppliers of green building products to bring their products and materials to the attention of the construction industry. Listings include a brief product description; supplier contact information and an assessment of the product. Published database that helps energy efficient companies to find partners and potential customers.

5.1.10 On-bill and tax repayment

Definition of activity

An approach where any recurring bill, such as utility bills, insurance bills or home improvement store bills, can collect small amounts of money over a long period of time to pay for energy efficiency purchases in smaller payments. An off-shoot of on-bill finance, tax repayment is where tax authority uses recurring tax payments as a means for collecting money over time. The most common of these is called PACE (Property Assessed Clean Energy) and is able to use low interest loan repayments on the property tax bill until the purchase is full paid.

Describing the status quo of tier groups

- Early Development: N/A
- Moderate Development: N/A
- Advanced Development: According to RISE Regulatory Indicators for Sustainable Energy by World Bank, on-bill and tax repayments are not applicable in some of the advanced development countries.

Case Study

PROSOL: Financing Solar Water Heating in Tunisia

PROSOL is an end user financing facility which was jointly developed by the Tunisian Ministry of Industry, Energy and Small and Middle Size Enterprises (MIEPME), the National Agency for Energy Conservation of Tunisia (ANME) and the UNEP.

The programme aimed at replacing fossil energies water heaters, in particular liquid petroleum gas, which is highly subsidised by the government. The programme accelerated the penetration of SWH in the residential sector by involving a number of local financial institutions to provide credit lines to end users, to help them overcome the barriers of the initial costs of SWH.

How PROSOL works

- For Suppliers: A VAT and customs duties exemption for finished or semi-finished products and raw materials.
- A top-down and bottom-up quality assurance for all suppliers and their products to be approved and marketed within the programme framework to ensure aftersales service and improve the public image of the solar water heater
- For end users: A direct public subsidy for buying a solar water heater of around 20%. The remaining costs of the solar water heater (approximately 80%), a direct simplified access to bank financing with credit recovery over 5 years to be attached to the electricity bill.

5.1.11 Community finance and crowdfunding:

Definition of activity

Collective funding from a large number of people connected either locally or through a call for funding.

Describing the status quo of tier groups

- Early Development: No community finance and crowdfunding mechanism for sustainable buildings.

- Moderate Development: No community finance and crowdfunding mechanism for sustainable buildings.
- Advanced Development: Several opportunities and platforms of community finance and crowdfunding.

5.2 Capacity building and awareness raising

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

5.2.1 Training within government

Definition of activity

Build capacity and awareness in all levels of government on the implementation of sustainable new building and their benefits, including for infrastructure, public health and wellbeing, the energy sector, and the environment.

Describing the status quo of tier groups

- Early Development: Training and capacity building of public sector staff on development of urban plans was conducted by UN-Habitat in many countries.
- Moderate Development: Training courses on energy efficiency and financing procedures are available.
- Advanced Development: Continuous workshops on the energy and water efficiency policy for government buildings to support an effective, thorough implementation of the policy as well as provide energy management training to energy efficiency related members from the government sector.

5.2.2 Training of professionals

Definition of activity

Provide training programmes for service and product providers of buildings and construction (architects, developers, contractors, vendors, etc.) and building owners are aware of sustainable new building policies, programmes, or incentives to implement sustainable buildings and construction.

Describing the status quo of tier groups

- Early Development: UN-Habitat introduced for many countries the environmental-friendly durable, cost-effective Stabilized Soil Blocks (SSBs) technology for reconstruction of public facilities.
- Moderate Development: Different entities provide trainings for professionals as: GPRS, Green Heath Code, Sustainable Construction Development, GBC Development and ASHRAE codes. Also, PA-CEMP is an in-depth professional certification programme for energy managers tailored for the Arab region. PA-CEMP aims to assist organisations and programme administrators in planning and implementing energy efficiency programmes and measures in the Arab region.

- Advanced Development: Energy Efficiency Program as a market-influencing and capacity building platform to facilitate the reduction of the carbon footprint through energy efficiency retrofits of existing inefficient buildings.

Case Study**Pan Arab- Certified Energy Management Professional Program (PA-CEMP)**

Pan Arab Certified Energy Management Professional Program (PA-CEMP) is a professional certification programme endorsed by the Executive Bureau of the Arab Ministerial Council of Electricity in their 32nd session on 31 May 2016, and developed in collaboration with the Regional Center for Renewable Energy and Energy Efficiency (RCREEE).

Building capacities of the buildings and construction sector relevant stakeholders on:

- **Sustainable building technologies** focusing on the main building components (i.e. building envelope, heating and AC systems, electrical systems, process equipment and domestic appliances). In this sub-activity, target groups will learn on the bandwidth of technologies available in the market, with a special emphasis on the best available technologies (highest energy efficiency).
- **Building energy efficiency practices** employed at the different building lifecycle stages starting from project inception and design, construction activities, throughout the operation and maintenance of all building components. In this sub-activity, the target audience will gain a deep understanding and macroscopic view of the integration between building components and building systems to ensure the efficient design, construction, and operation of sustainable buildings.

5.2.3 Educational training**Definition of activity**

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

Describing the status quo of tier groups

- Early Development: Based on interview with national experts, educational trainings are newly introduced in the syllabus of some technical universities.
- Moderate Development: Some Universities host event and Awareness workshops in-person and online.
- Advanced Development: Educational initiatives work on engaging students through expansive lesson plans, animated videos, and activities on its interactive web portal to encourage environmental innovation, creativity & recycling habits among students. This proves the work on the capacity building in the educational sector on different levels.

5.2.4 Awareness and information**Definition of activity**

Develop information tools for people to have increased awareness, improved decision-making and to promote more sustainable choices. Methods of increasing information to consumers include benchmarking programmes, certification programmes, building passports, mandatory disclosure, labels, educational resources, and information on utility and government programmes.

Describing the status quo of tier groups

- Early Development: Some initiatives aim to raise the awareness of sustainability.

- **Moderate Development:** Several internationally funded projects are associated with components of capacity building and awareness activities. Among these projects are UNDP project (Improving Energy Efficiency of Lighting & Building Appliances), BUILD_ME, and Cool up.
- **Advanced Development:** Multiple and different activities towards energy efficiency and conservation, including announcing different strategies, and different related events.

Case Study

Green Star Hotel Initiative Development



The Green Star Hotel Initiative (GSH) resulted in increased use of renewable energy (up to 25%) and a significant reduction in water, energy and chemical consumption (up to 30%) and in the GSH certified hotels (Talaat 2014).

- The GSH Initiative, which started as a national green certification and a capacity building programme, was introduced in 2007 to encourage the Egyptian Hotel Industry to 'go Green' or promote sustainable tourism.
- The GSH initiative encourages the implementation of environmentally friendly practices such as committing to increasing the rate of energy efficiency and contributing to ensuring universal access to affordable and reliable energy services (Abdou et al. 2020).
- Currently, the Green Star initiative includes 76 hotels, 18,552 rooms in 15 destinations country-wide (Egyptian Hotel Association 2022).

5.2.5 Institutional coordination

Definition of activity

Coordination and shared goals between relevant government and non-government organisations can enable improved policy consistency. Enable technical, financial, and human capacity for the implementation and enforcement of sustainable new buildings policies.

Describing the status quo of tier groups

- **Early Development:** N/A
- **Moderate Development:** Few trainings on policies and energy efficiency actions related to building energy efficiency are provided.
- **Advanced Development:** Collaboration between public sector and the professional stakeholders aiming to facilitate the exchange of experiences and practices, review the development of training systems, stimulate capacity building and advance the energy transformation process.

5.2.6 Other capacity building efforts

Awareness of procurement models

Definition of activity: Promote the use of alternative procurement models such as bulk procurement, energy performance contracting, benchmarking, green leasing and incentives to reduce the cost of new efficient and sustainable buildings. Increase the capacity of financial service providers to implement the range of innovative financing models.

Describing the status quo of tier groups

- Early Development: N/A
- Moderate Development: N/A
- Advanced Development: Energy Saving Performance Contracting (ESPC) projects on-going. These projects aim to improve energy efficiency in the buildings while generating savings and reducing costs to building owners, tenants, and the government, also, support the widespread of Super ESCOs as an effective economic impact.

5.3 Engagement across multiple stakeholders

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

- Stakeholders to be engaged are listed below. Some of these cover different sectors that may not efficiently coordinate or collaborate:
- National government: National governments design and implement policies that enable or disable the uptake of sustainable buildings and construction. National governments act as regulators and can play an important role in facilitating partnerships among other stakeholders.
- Subnational government: Subnational governments play a critical role in developing, implementing, and enforcing policy. In addition to their regulatory role, cities and states can convene actors across sectors, and can act as owners of public buildings.
- Utility companies: Utilities have significant building data and valuable relationships with owners and tenants that already includes payment and financing. In some cases, utilities also have to comply with legislation to reduce their emissions. Utilities can therefore be either a significant barrier or enabler to action on sustainable buildings and construction.
- Property and project developers: Developers make decisions about how property will be used, including cost-benefit assessments for different buildings and construction approaches. These early decisions can have far-reaching impacts into what options are considered in a building or construction project.
- Financial institutions: Financiers provide mechanisms to make the necessary upfront investments for sustainable buildings and construction, with repayment often coming from the energy-saving benefits that develop over several years.
- Architects and engineers: Professionals who lead on technical project design and determine what is possible within the parameters set by developers. Professional and educational training provides these experts with the knowledge they need to develop sustainable buildings and construction designs.
- Manufacturers and suppliers: Companies that make equipment and systems determine what products are available on the market, and whether building upgrade solutions are sold with a systems-view or more piecemeal replacements over time.

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

	Act 1 Urban planning	Act 2 New buildings	Act. 3 Buildings retrofit	Act. 4 Building operations	Act. 5 Systems	Act. 6 Materials	Act. 7 Resilience	Act. 8 Clean Energy
National Gov.		●	●		●	●	●	●
Subnational Gov.	●	●	●				●	
Implementing agencies/actors	●	●	●	●				●
Building authorities and housing asso.	●	●	●	●	●			
Architects and engineers	●	●	●		●	●		
Property developers		●	●			●		
Utility companies/ municipal service auth.	●							●
Sustainable service providers + FM				●	●			
Civil society							●	
Sustainable product providers		●	●			●		●
Researchers					●	●	●	●
Financial institutions		●	●				●	●
Training and capacity institutions/providers				●		●		
Local community and business asso.							●	●

Key message. Highlighting the most relevant stakeholder per activity

Figure 34. Stakeholder mapping.

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

6. Outcomes: multiple benefits (direct and co-benefits)

6.1 Overview of multiple benefits

The buildings and construction sector comprehensively impacts our society. Buildings are where we live, work, entertain and spend most of our time. Buildings are constructed using materials and products created by the industrial sector and delivered to buildings through the transport sector. This wide-reaching impact of a single sector enables many wide-reaching benefits if the buildings can achieve the targets set out in this roadmap. The figure in below illustrates multiple benefits and which activities they mainly occur.

	Act 1 Urban planning	Act 2 New buildings	Act. 3 Buildings retrofit	Act. 4 Building operations	Act. 5 Systems	Act. 6 Materials	Act. 7 Resilience	Act. 8 Clean Energy
Emissions Savings	●	●	●	●	●	●		●
Air Quality	●	●	●	●	●	●		●
Resource efficiency	●	●	●		●	●	●	
Energy Savings	●	●	●	●	●	●	●	●
Energy Prices	●	●	●	●	●			●
Economic	●	●	●	●		●	●	●
Productivity	●	●	●	●	●		●	
Asset Value		●	●	●	●	●	●	●
Poverty alleviation	●	●	●	●	●		●	
Employment		●	●	●				●
Health and Well-being	●	●	●	●	●	●	●	
Safety and security	●	●	●	●	●	●	●	
Energy security	●	●	●	●	●	●	●	●

Key message: Energy efficiency, resource efficiency, and renewable energy measures do not just save energy and GHG emissions—they can also result in multiple benefits like increasing health, prosperity, and security.

Figure 35. Multiple benefits of the Global ABC activities.

In the context of decarbonisation in the built environment, the benefits are also often differentiated between direct benefits and co-benefits. With energy savings, GHG savings and energy cost reduction being perceived as direct benefits and other ones like job creation, energy security, poverty alleviation and many more are categorised as co-benefits. In the following some selected examples for both types of benefits are presented, that are relevant for the Arab region.

6.2 Energy and emission savings (direct benefit)

Under the BUILD_ME¹² project several pilot projects have been supported in its ambitions to improve their energy performance. The presented case study is a university building situated in Mansoura City Development. This new quarter is on the coast of the Mediterranean Sea developed by the New Urban Community Authority of the Ministry of Housing in Egypt. A Building Energy Performance (BEP) Tool, which was developed within the BUILD_ME project, was used to calculate energy consumption of the central library building of Mansoura University. Analysis of the cost-optimal energy efficiency and renewable energy measures with the BEP Tool showed that the following components would be cost-effective and will be considered for further planning:

- Improvement of the building envelope, Solar glazing, Higher efficiency variable refrigerant flow system, PV on the roof

The suggested measures lead to a significant decrease in energy demand and cost savings. Reduced energy demand ranges between 26% and 90% compared to BAU. Global cost savings reach 24%-51%.



Figure 36. Mansoura University in Egypt

¹² <https://www.buildings-mena.com/info/pilot-projects>

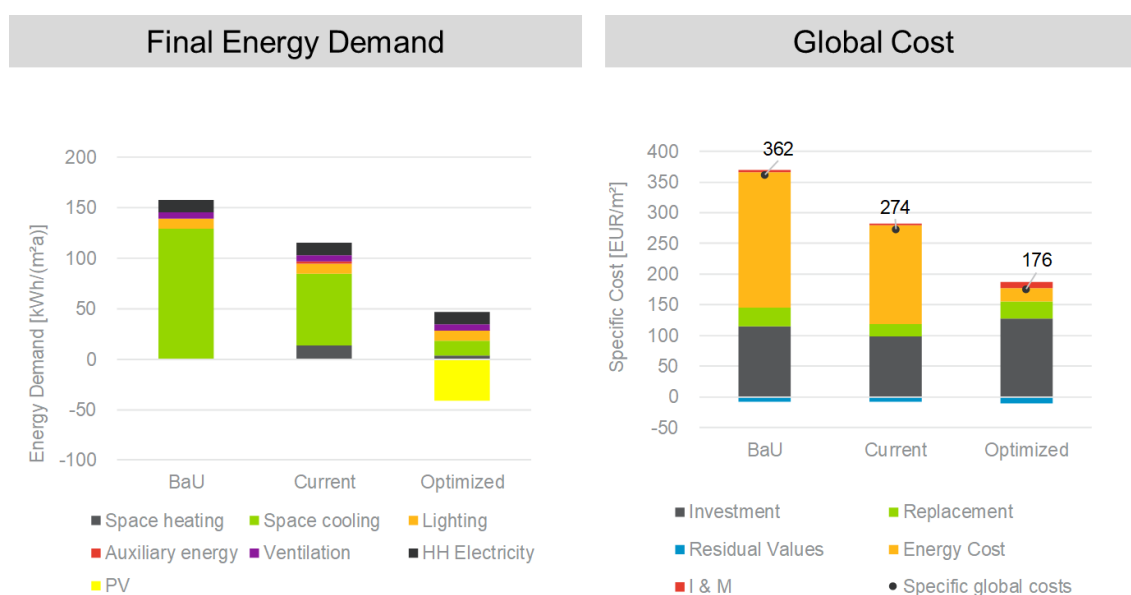


Figure 37. BEP Tool results of the Mansoura project.

6.3 Energy prices and removal of subsidies (co-benefit)

Energy subsidies are a significant obstacle for sustainable economic and social development in the Arab region. They distort economic growth and employment, are socially and politically divisive and negatively impact the climate and the environment. They form a barrier to energy efficiency and renewable energy, encouraging waste, inefficiency, and environmental damage. Finally, energy subsidies are putting an increasingly unsustainable strain on public finances. The fact that subsidies are a poor mechanism for poverty reduction, as they disproportionately benefit the rich, and lock the country into economic inefficiency provides powerful arguments for reform. However, many groups still rely on subsidies and therefore reform is a challenge. Fairness and transparency are key principles in overcoming this challenge and are at the heart of the active communication strategy.

And not only do subsidies of fossil fuels bring many disadvantages but there are many benefits to their removal. For example, subsidy costs can account for a large share of government expenditures in selected Arab countries, by removing subsidies the saved money can be spend on economic development, infrastructure, education, and health. When subsidies are removed the saved energy and money can be invested in better service and higher efficiency in the energy sector which can ultimately result in savings millions/year due to avoided fuel costs. The reformation of energy subsidies can benefit the investment in renewable energy solutions which can create skilled jobs in this sector. The money saved could also be used to increase the income of people via lower taxation, incentives or other means. This would protect against poverty. Furthermore, the removal can help to distribute the national wealth fairly and equally and to minimise income disparities. Energy efficiency can be increased, and wasteful consumption prevented.

6.4 Employment creation (co-benefit)

Energy efficiency investments in the buildings sector have a positive impact on employment creation. Energy efficiency requires people on the ground and many of the materials and some technologies can be manufactured locally. The jobs range from relatively low skilled construction and manufacturing work to higher skilled work in training and professional buildings services provides an overview of the range

of jobs, a summary of how these jobs relate to each other, the relative size of the employment creation opportunity and the level of qualification required. With the largest number of jobs in lower qualified construction positions and the smallest number of jobs in higher qualified auditing roles.

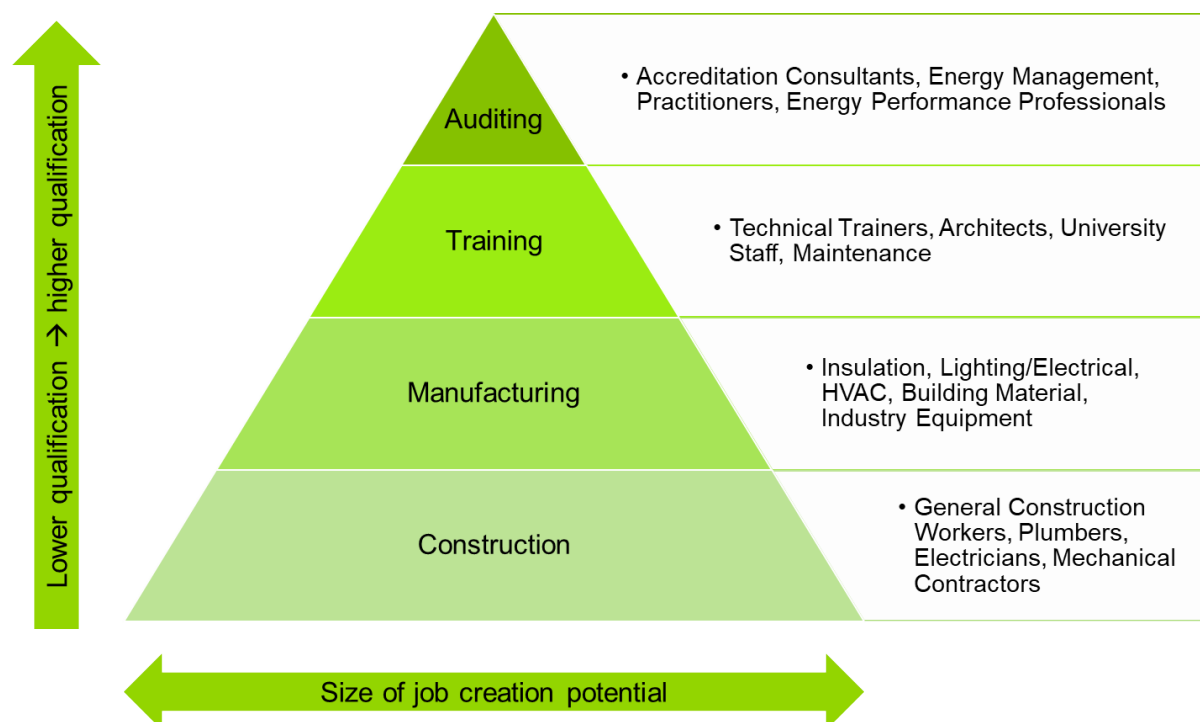


Figure 38. Types of jobs generated by energy efficiency in buildings investments.

6.5 Energy security (co-benefit)

Lebanon imports approximately 100% of its oil demand, with imported oil accounting for approximately 25 per cent of its national budget deficit (IRENA 2020b). Further, there is a huge demand-supply imbalance, which is reflected in the capacity reserve margin of -27 per cent (Ersoy et al. 2021). The shortage of supply is further exacerbated by increasing electricity demand, which has increased by an average annual growth rate of 7.6 per cent since 1990 (Ersoy et al. 2021). In 2018, the shortage of supply reached 19 TWh, induced by population growth (Ersoy et al. 2021).

In 2019, Lebanon needed an additional 1,500 MW (approx.) to meet its overall demand (Ersoy et al. 2021). The peak consumer demand was estimated at 3,669 MW for the year, whereas the effective generation capacity was in the range of 1,800 MW-2,000 MW (Ersoy et al. 2021). Besides the gap in energy demand and supply, Lebanon suffers from structured blackouts that average around 6 hours a day (Harajli et al. 2019). In 2020, the blackouts lasted 22 hours per day during certain days (Azar 2021), (Majzoub 2020).

In addition to adhering to its commitments, Lebanon addressed the issue of energy security in several policies and plans. Lebanon has recently updated its renewable energy target and set ambitious one which is 30% of its electricity consumed in 2030. Furthermore, Lebanon had already introduced policies such as the NREAP, the NEEAP 2011-2015, and the NEAAP 2016-2020. Nevertheless, much more needs to be done to transform the energy sector in Lebanon and achieve energy security for its citizens. First, appropriate institutions and structures with clearly defined roles need to be established to implement stable and integrated renewable energy deployment. Second, better participatory tools and mechanisms in the

energy transformation process should be designed to achieve fair power dynamics and energy policies. Lastly, investment in R & D will be crucial for creating local value chains through rapid renewable energy deployment and enhanced energy security, which is also a pre-requisite for economic growth.

7. Guiding principles for setting up roadmaps

7.1 Guiding principles for roadmap design

This report focuses on policy development and technology solutions, as they are both impacting the current and future configuration of the buildings sector. An important factor to keep in mind during the analysis of barriers and drivers for a climate neutral buildings sector is the human factor. Not technologies and innovative solutions alone can pave the way, but the involvement and commitment of a wide range of stakeholders engaged in change and transition are crucial.

Regarding guiding principles for roadmap design, it is important to embrace the full context of the activities to **understand the current situation and develop measures accordingly while estimating and monitoring the impacts**. It is crucial to accept the complexity and interdependency of the matter as a solution to find appropriate measures and not as barrier. As stated in the multiple benefits chapter (see Chapter 6) it is important to not only focus on CO₂ reduction, but to recognise, that impacts will occur in all areas of sustainability, which can potentially provide many strong arguments for integrated approaches. It is important to see that appropriate action must respond to the individual context. The roadmap should be understood as merely an entry point or menu that needs to be adapted further, precisely to a **country-specific context**. And as mentioned before, **stakeholder support** for planned measures and instruments is very important as all measures in one form or another ask for a behavioural change of stakeholders involved. Furthermore, the governmental and spatial dimension of climate action should be considered accordingly: policy and planning should refer and be in line with the various scales, from the single building, to district, city, region, country and eventually the supranational level.

The roadmap addresses all aspects that have been identified as crucial for a transformation across all relevant areas and levels. This highlights how strongly the activities are interconnected.

- **Political level:** Governance of climate change is influenced and organised through institutions across scales and through networks and partnerships. It is a multi-level and multi-actor process. A further understanding of the **interaction between policies and actions** at different levels and how it affects the transition of the buildings sector must be established. Collaboration between policy and technical stakeholders and academia is relevant as well.
- **Economic:** A broader knowledge on **financing opportunities and mechanisms** that can support climate change agendas is needed. To integrate climate considerations into fiscal and financial decision-making, new frameworks and tools must be developed. Further information on private investments and the role of public finance is useful, especially where projected returns are considered too low or too risky to attract private finance.
- **Sociological:** A deeper knowledge on the emissions reduction potential of buildings and on how inequalities and energy poverty can be addressed is needed to best support climate action in the sector. **Raising awareness among people and local businesses** is essential, formulating clear messages on the benefits of decarbonised buildings. Another important aspect is to ensure that energy prices reflect the real social and environmental costs. Setting the right incentives is important, because the

low prices of fossil fuels compared to clean energy sources prevent actors from investing in energy efficiency and clean energy.

- **Technological:** Taking a systems approach in the search of solutions for the decarbonisation of the buildings sector is important, especially on climate change mitigation and adaptation strategies. A systems approach recognises that the buildings sector and other sectors are interdependent and interacting. A **holistic approach** is needed to integrate a wide range of knowledge, technology and data into a roadmap design.
- **Legal:** Guidance for regulations and policy design should follow a 'fit-for-purpose' approach. It should consider the recipient's perspective by **developing a long-term roadmap and interim targets**, so that stakeholders can prepare for its ambitious level and its requirements. Methodologies and tools that can identify sources of risks and uncertainty need to be developed accordingly.
- **Environmental:** In the buildings sector relevant aspects of change (economic, social and cultural) are represented. It is well positioned to test interesting opportunities in terms of production and consumption patterns that could significantly **promote low-carbon lifestyles**, enable climate resilience and improve the overall quality of life. To support these goals, a gradual transition to more efficient and sustainable production and consumption patterns is particularly important.

7.2 Recommendations for policy design

The following instruments can be used depending on the specific case and situation:

- **Regulatory framework:** The first step should be to plan a strategy with a participative approach that includes all relevant stakeholders. The strategy should include short-, mid- and long-term measures and goals and follow the policy design cycle principle. Instruments to implement said strategy must be transferable (cost based), they must be regularly updated and easy processes to support enforcement.
- **Financial instruments:** Unfavourable economic boundary conditions are the greatest obstacle to enhancing energy efficiency in buildings (e.g. distorted energy prices, too high pay back periods for sustainable measures). To overcome this barrier, financial incentives for property owners and green finance mechanisms for public authorities should be offered.
- **Awareness:** All buildings sector programmes initiated should be target-oriented. The usage of new media channels helps to spread the information further, especially when not only facts are shared, but convincing stories inspire the target audience.
- **Training:** Specific programmes and training courses should target main actors of the planning and implementation phase. Encourage mandatory trainings loops and establish training centres also supported by the private sector to offer vocational trainings for craftspeople and other relevant parties.
- **Innovation:** Encourage local simple and passive low tech solutions partly based on old vernacular architectural concepts merged with new technologies. It is important to promote resource efficiency, to highlight the benefits of a circular economy and to support local value chains.

8. Conclusion and outlook

This 2020-2050 Global ABC roadmap for the Arab region provides guidance towards a sustainable buildings and construction sector for what is a diverse and large region. To put this into perspective, we would like to briefly summarize the approach taken in this report and further steps to come.

This report considers 22 countries. The overall transformation towards a sustainable buildings and construction sector is broken up into eight comprehensive activities, which are intertwined. An in-depth collection of information of the 22 countries has been achieved, confirming the significant diversity in approaches and status quo—but above all, this information provides amazing examples for best practices and progress across all eight activities.

It is understood that all Arab countries know best about their buildings and construction culture, processes, and stakeholders. Therefore, we would like to stress that while trying to reflect the region's diversity in the best possible way, the report should not be understood as presenting any kind of prescriptive “that is the way to do it” activities. Its purpose is to present a non-exclusive menu of instruments and actions, underpinned by best practice examples, thus providing input into the strategy and decision-making process that every Arab country needs to adapt to their individual context.

This individuality is reflected in the setup of this report. While providing guidance and input to the whole Arab region's transformation of the buildings and construction sector, which is ongoing and with many activities ahead, it takes note of different degrees of maturity an Arab country may have reached relative to each of the eight activities. Depending on how advanced a country evaluates itself relative to an activity—early starter, moderately advanced, or advanced—it can pick the most suitable roadmap guidance.

Countries have been assigned to one of those development phases in this report for illustration purposes. A country that has been labelled as moderately advanced in general, could be an early starter or advanced in selected activities. However, that is not the level of granularity aimed for in this report.

What does this mean for next steps towards a sustainable buildings and construction sector in the Arab region? This roadmap is an interim step on that pathway. It is meant to help all countries map themselves relative to their development phase in each of the eight activities. The roadmap also provides guiding principles for countries' individual roadmaps and policy designs, which is an essential ingredient to their next step of designing individual country roadmaps.

In developing such individual roadmaps, Arab countries will be able to consider their individual context and reality (i.e. climate, building culture, local industry, and economy), existing policy framework, and other resources. The authors of this report will be grateful if this roadmap initiates or supports discussion in countries in the Arab region and leads to setting up or facilitating one or more country roadmaps.

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Acronyms, abbreviations, and units of measure

3D	three dimensional
AC	air conditioner
ADWEA	Abu Dhabi Water & Electricity Authority
AFEX	Arab Future Energy Index
AIIB	Asian Infrastructure Investment Bank
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BAT	best available technology
BEEC	building energy efficiency code
BESS	battery energy storage systems
BIM	building information modelling
BSOE	Bee'ah School of Environment
CDD	cooling degree day
CDP	Carbon Disclosure Project
CIB	Commerce International Bank
CO ₂	carbon dioxide
COP	coefficient of performance
CSP	concentrated solar power
CVRA	climate vulnerability and risk assessment
DEWA	Dubai Electricity and Water Authority
DGF	Dubai Green Fund
DoE	Department of Energy
DM	Dubai Municipality
DSCE	Dubai Supreme Council of Energy
DSM	Demand-side management
EBRD	European Bank for Reconstruction and Development
ECAS	Emirates Conformity Assessment Scheme
EE	Energy efficiency
EEBC	Energy Efficiency Buildings Code
EECBC	Energy Efficiency for Commercial Buildings Code
EER	energy efficiency ratio
EERBC	Energy Efficiency for Residential Buildings Code
EESL	energy efficiency standards labelling
EGA	Emirates Global Aluminium
EMS	energy management systems
EOS	Egyptian Organization for Standards and Quality
EPC	energy performance certificate
EPC	engineering, procurement, and construction
EPD	Environmental Product Declaration
ESCO	energy services company
ESCWA	Economic and Social Commission for Western Asia

ESG	environmental, social and governance
ESMA	Emirates Authority for Standardization and Metrology
ESPC	Energy Saving Performance Contracting
EU	European Union
EUI	energy use intensity
EUR	Euro
EWS	Emirates Wildlife Society
FAB	First Abu Dhabi Bank
FEI	Federation of Egyptian Industries
FIT	feed-in tariffs
GBC	Green Building Council
GCC	Gulf Cooperation Council
GCF	Green Climate Fund
GDP	gross domestic product
GEFF	Green Economy Financing facility
GFDRR	Global Facility for Disaster Reduction and Recovery
GIS	geographic information system
GIZ	German Development Cooperation
GHG	greenhouse gas
Global ABC	Global Alliance for Building and Construction
GPRS	Green Pyramid Rating System
GWP	global warming potential
HBRC	Housing and Building National Research centre
HDD	heating degree day
HPD	Health Product Declaration
HVAC	heating, ventilation, and air conditioning
IDP	internal displaced person
IEA	International Energy Agency
IFC	International Finance Corporation
IISD	International Institute for Sustainable Development
ILFI	International Living Future Institute
IPP	independent power producer
IRENA	International Renewable Energy Agency
ISDF	Informal Settlements Development Facility
ISO	International Standards Organization
IUWM	Integrated Urban Water Management
KPI	key performance indicator
KfW	Kreditanstalt für Wiederaufbau
LCA	lifecycle assessment
LED	light-emitting diode
LEED	Leadership in Energy and Environmental Design
LFP	lithium iron phosphate

low-e	low-emissivity
MENA	Middle East and North Africa
MEPS	minimum energy performance standards
MOCCAE	Ministry of Climate Change and Environment Development
N/A	not available
NBE	National Bank of Egypt
NBK	The National Bank of Kuwait
NBKE	The National Bank of Kuwait in Egypt
NDC	nationally determined contribution
NGK	Nihon Gaishi kabushikigaisha
NEEAP	national energy efficiency action plan
NFPA	National Fire Protection Association
NREA	New and Renewable Energy Authority
NREAP	National Renewable Energy Action Plan
NREL	National Renewable Energy Laboratory
NUCA	New Urban Communities Authority
OECD	Organization for Economic Co-operation and Development
O&M	operations and maintenance
PACE	property assessed clean energy
PA-CEMP	Pan Arab Certified Energy Management Professionals
PCR	Product Category Rules
PJSC	Public Joint Stock Company
PPA	power purchase agreement
PPP	purchasing power parity
PV	photovoltaic
QNB	Qatar National Bank
R&D	research and development
RACI	responsible, accountable, consulted, informed
RAR	Regional Assessment Report
RCREEE	Regional Center for Renewable Energy and Energy Efficiency
RISE	Regulatory Indicators for Sustainable Energy
RSB	Regulatory and Supervisory Bureau
SSB	stabilised soil block
SEC	Supreme Energy Council
SEER	seasonal energy efficiency ratio
SHGC	solar heat gain coefficient
SMART	specific, measurable, achievable, realistic, and timely
SMEs	small and medium-sized enterprises
SSL	solid-state lighting
ST+PV	solar thermophotovoltaics
SUDEP	Sustainable Urban Demonstration Projects
SWHS	solar water heating system

TARES	Technical Assistance to Support the Reform of the Energy Sector
TCFD	Task Force on Climate-Related Financial Disclosures
TES	thermal energy storage
TFEC	total final energy consumption
ToU	time of use
VIU	vertically integrated utilities
VLT	visible light transmission
WHO	World Health Organization
WUI	water use intensity
WWF	World Wildlife Fund
WWR	window/wall area ratios
TOD	transit-oriented design
UAE	United Arab Emirates
UN	United Nations
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
UNEP	United Nations Environment Programme
UNICEF	United Nations International Children's Emergency Fund
UNIDO	United Nations Industrial Development Organization
UNISDR	United Nations International Strategy for Disaster Reduction Secretariat
USD	United States dollar
ZC	Zero Carbon
ZE	Zero Energy
PESTLE	Political, Economic, Sociological, Technological, Legal, and Environmental

Units of measure

°C	degrees Celsius
ACH	air change per hour
Fils	The UAE Dirham is subdivided into 100 Fils
GW	gigawatts
GWh	gigawatt-hour
kWh	kilowatt-hour
kWh/m ² a	kilowatt hour per unit square metre
L/s/m ²	Litre per second per square meter of window area
m	metre
m ²	square metre
m ³ /h	cubic metre per hour
m ³ /h/m ² cubic	metre per hour per square metre
MW	megawatt
PA	Pascal
tCO ₂ eq	Carbon dioxide equivalence

TWh	terawatt-hour
W/m ²	watts per square metre
W / m.	watts per metre, per degree Celsius
W/m ² K	watts per square metre, per degree Kelvin

9. Annex: Deviations compared to the Global ABC roadmap template 2020

This table is a comparison between the contents of the current report and the Global ABC template, 2020. The changes are highlighted in red according to the following:

- The red text (sub-activities) in this report structure indicate added sub-activities from older versions of Global ABC Roadmaps. The red highlighted titles indicate the merge between two chapters according to the Arab region context.
- The red highlighted contents within the reference report indicate sub-activities that were omitted, merged, rearranged, or adapted in the structure of this report.

Global ABC Regional Roadmap for Buildings and Construction in the Arab Region 2020-2050 (This report)	Global ABC Roadmap for Buildings and Construction 2020-2050 (Reference report)
1.1 Policy for urban planning: • Integrated urban planning • Zoning regulation • Location efficiency and transit-oriented design • Spatial and vertical integration	1.1 Policy for urban planning: • Integrated urban planning • Location efficiency and transit-oriented design • Urban heat island mitigation • Incentives
1.2 Technology for urban planning: • Digital tools • District energy • Exterior lighting • Water management • Urban ecology	1.2 Technology for urban planning: • Data collection and monitoring • Information systems and tools • Street lighting • Water management • Waste management • Vegetation
2.1 Policy for new buildings and buildings retrofit • Building energy efficiency codes and its compliance (new buildings) • Codes for existing buildings and compliance • Informal buildings sector • Building labelling (Energy Performance Certificate) • Building sustainability certification • Energy retrofits plan • Energy audits for existing buildings	2.1 Policy for new buildings • Building energy codes • Compliance with building codes • Participation of the informal sector • Building labelling • Labelling of building components • Building passports • LCA • Incentives
	2.1 Technology for new buildings Building envelope • Passive design • External shading • Reflective surface finishes • Insulation • Windows (thermal) • Windows (solar) • Daylighting • Design tools

Global ABC Regional Roadmap for Buildings and Construction in the Arab Region 2020-2050 (This report)

Global ABC Roadmap for Buildings and Construction 2020-2050 (Reference report)

2.2 Policy for new buildings and buildings retrofit

- Passive design
- Building envelope (U-value)
- External shading
- Reducing solar gains using reflective surface and windows
- Windows (solar and thermal characteristics)
- Daylighting
- Air tightness
- Design tools

3.1 Policy for existing buildings

- Energy retrofits
- Codes for existing buildings
- Building refurbishments
- Building labelling
- Building passports
- Incentives

3.1 Technology for existing buildings

- Passive design
- External shading
- Reflective surface finishes
- Insulation
- Windows (thermal)
- Windows (solar)
- Daylighting

3.1 Policy for sustainable building operations

- Certification for operational performance
- Benchmarking
- Information campaigns

4.1 Policy for sustainable building operations

- Benchmarking
- Certification for operational performance
- Building passports
- Disclosure
- Energy audits
- Incentives

3.2 Technology for sustainable building operations

- Soft solutions: strategies and tools
- Technical equipment

4.2 Technology for sustainable building operations

- Maintenance tools
- Audit tools
- Building management systems (BMS)
- Energy management systems (EMS)
- Sensors and controls

4.1 Policy for systems (HVAC and lighting)

- Minimum performance standards
- Labels
- R&D
- Procurement

5.1 Policy for sustainable appliances and systems

- Minimum performance standards
- Labels
- R&D
- Procurement
- Incentives

4.2 Technology for systems (HVAC and lighting)

5.1 Technology for sustainable appliances and systems

- Space heating
- Mechanical cooling
- Ventilation
- Water heating
- Lighting
- Smart devices

Global ABC Regional Roadmap for Buildings and Construction in the Arab Region 2020-2050 (This report)
Global ABC Roadmap for Buildings and Construction 2020-2050 (Reference report)

- Mechanical cooling systems
- Space heating systems
- Ventilation
- Water heating systems
- Lighting
- Smart devices
- Appliances
- Energy storage

5.1 Policy for sustainable materials

- Information and awareness
- R&D
- Benchmark and disclosure
- Material labelling
- Minimum environmental standards

6.1 Policy for sustainable materials

- LCA
- Benchmarking and disclosure
- Material labelling or certification
- Minimum environmental standards
- Incentives
- R&D

5.2 Technology for sustainable materials

- Material (resource) efficiency
- Energy efficiency in material production
- Decarbonising materials production
- Locally produced materials
- Tools for resource efficiency

6.2 Technology and strategy for low-carbon materials

- Reduced embodied carbon
- Material efficiency
- Energy efficiency for materials manufacturers
- Decarbonise materials production
- Local material alternatives
- Tools for resource efficiency

6.1 Policy for resilience

- Risk mapping and impact assessment
- Resilience strategy
- Resilience in building codes
- Adaptation programmes for existing buildings

7.1 Policy for resilience

- Risk mapping
- Resilience strategy
- Resilience in building codes
- Adaptation programmes for existing buildings
- Data and monitoring

6.2 Technology for resilience

- Information systems and monitoring
- Community networks
- Management of extreme weather hazards
- Measures to increase resilience of buildings

7.2 Technology for resilience

- Social networks
- Adaptation tools to extreme weather
- Stormwater management
- Resilience of critical infrastructure

7.1 Policy for clean energy

- Distributed renewable energy
- Building codes
- Regulatory framework
- Reforming fossil fuel subsidies

8.1 Policy for clean energy

- Decarbonisation of the grid
- Decarbonisation of heat
- Distributed renewable energy
- Building codes
- Regulatory framework
- Reforming fossil fuel subsidies

7.2 Technology for clean energy
8.2 Technology for clean energy

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- Solar thermal
- Solar PV
- Geothermal heating or cooling
- Energy storage

Global ABC Roadmap for Buildings and Construction 2020-2050 (Reference report)

- Solar thermal
 - Solar PV
 - Cogeneration
 - Geothermal heating or cooling
 - Clean cooking
 - Energy storage
 - Waste to energy
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