



Global Alliance
for Buildings and
Construction

GlobalABC Regional Roadmap for Buildings and Construction in **Africa**

2020-2050

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



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Construction

GlobalABC Regional Roadmap for Buildings and Construction in Africa 2020-2050

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

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Executive summary

With the Paris Agreement countries have agreed to a common goal of maintaining the global temperature increase to well below 2 degrees, and preferably no more than 1.5 degrees, by the end of the century. According to the latest UNEP Emissions Gap report, to be on track for the 1.5 degree goal, the world needs to reduce global emissions by over 50% by 2030 and work towards carbon neutrality by 2050. As the buildings and construction sector accounted for 36% of final energy use and 39% of energy and process-related carbon dioxide (CO₂) emissions globally in 2018, it will have to play a major part in achieving this vision.

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In 2018, the African buildings sector accounted for 61% of final energy use and 32% of energy-related carbon dioxide (CO₂) emissions, excluding emissions from manufacturing building materials and products such as steel, cement and glass (IEA, 2019a). Since 2010, growth in emissions has been driven by a 23% rise in regional population and a 25% increase in wealth (gross domestic product), which has increased the demand for floor area and for energy consuming services (IEA, 2019a). These pressures will continue as Africa's population is expected to grow by 63% and could more than double its economic wealth by 2040.

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

According to the *World Energy Outlook*, energy efficiency and decarbonisation measures under a Sustainable Development Scenario¹ in buildings in Africa could reduce overall energy demand by 40% by 2040, while seeing a three-fold increase in electricity demand and a 24% reduction in building CO₂ emissions (IEA, 2019b). These actions would result in a contribution of over 330 MtCO₂ reductions in annual emissions by 2040, compared to the current course of action under the Stated Policies Scenario.²

Achieving these outcomes at pace and scale will require greater collaboration among policy makers at all jurisdictional levels, as well as with urban planners, architects, developers, investors, construction companies and utility companies. With appropriately designed and implemented policies and the adoption of a range of cost-effective technologies, including high-efficiency lighting, passive design, material efficiency, low-carbon materials, and efficient building envelopes, substantial improvements in Africa's building quality and energy performance can be achieved. In turn this would support greater energy access, improved wellbeing, resilience and energy savings across the building life cycle. Decarbonising buildings is also in full alignment with the aims of SDG 12, to ensure sustainable consumption and production patterns.

To unlock these improvements in African buildings will require clear and ambitious policy signals that address socio-economic imbalances, access to clean fuels, existing market failures, and encourage economies of scale. Such actions can enable further innovation in building products and services and financing solutions.

Yet, in the region, progress on building energy codes is slow and not keeping up with increasing demand for new buildings, which is driven by the growth in population and urbanisation

¹ As well as meeting the energy-related UNFCCC Sustainable Development Goals in full, the Sustainable Development Scenario (SDS) is fully aligned with the Paris Agreement, holding the global average temperature rise to below 1.8°C with a 66% probability without reliance on global net-negative CO₂ emissions.

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

(GlobalABC/IEA/UNEP, 2019; IEA, 2019b). Very few countries have mandatory or voluntary codes or certification programmes, though several are under development.

The purpose of this roadmap is to support a common language and vision for the complete decarbonisation of buildings across their life cycle, and to support the development of national or subnational strategies and policies, including for example, Nationally Determined Contributions (NDCs).

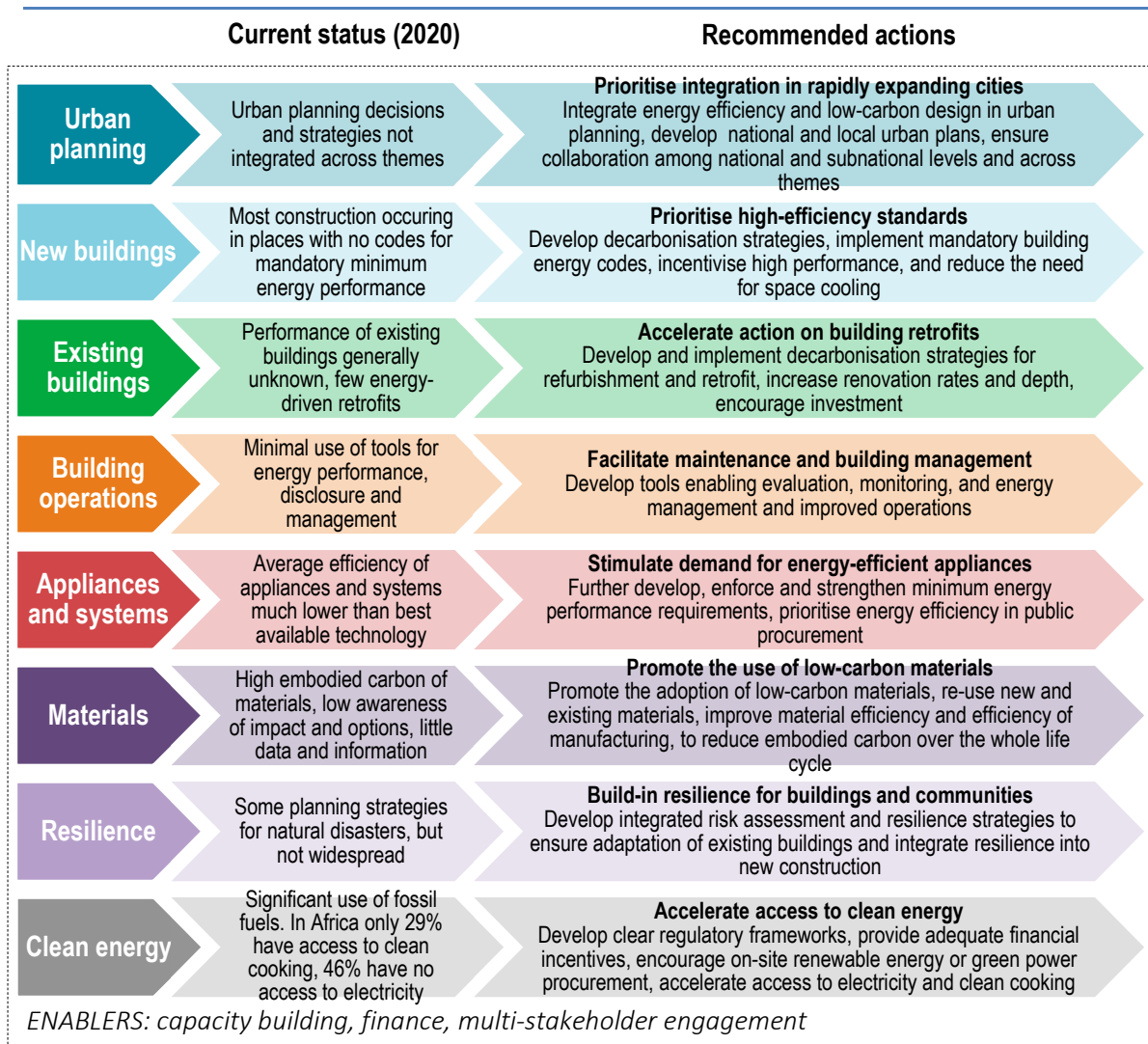
It covers eight “activities”: urban planning, new buildings, existing buildings, building operations, appliances and systems, materials, resilience and clean energy, and for each of these proposes key actions, targets for policies and technologies, and enabling measures with the aspiration of reaching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

The Africa Roadmap was developed in consultation with over 120 stakeholders and buildings experts across the continent who provided input to collectively build the timelines across the eight activities.

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

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

Figure 1 • Africa Roadmap summary timelines



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Key actions and strategy

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

Based on extensive stakeholder consultation and analysis, the following actions can achieve progress towards zero-emission, efficient and resilient buildings.

National roadmaps and strategies set priorities for the sector

National ministries and city agencies should develop ambitious, comprehensive strategies and roadmaps to outline the pathway towards greater access to clean energy, and affordable developments that support zero-emission, efficient and resilient buildings and construction. These strategies should focus on setting out clear targets and policies for building performance and integrated planning to address anticipated future growth in building construction across the African region.

Governments should partner with key stakeholders to develop metrics which include energy performance benchmarks and sector targets and data collection mechanisms that include the use of materials with low embodied carbon, building energy performance, building ratings systems and building resilience.

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

Governments and industry coalitions should work to close key information gaps by establishing data collection systems and methodologies that can provide essential evidence to inform decarbonisation and efficiency planning, as well as highlight the concrete, quantifiable benefits of efficiency and sustainability interventions.

Local agencies should undertake risk mapping and resilience assessment and develop integrated strategies to improve the resilience of the building stock and develop strategies to address resilience risks in new building developments to inform zoning and building performance standards.

Standards and codes gradually drive up performance

Regulators can reduce future energy demand in new buildings through ambitious and progressive mandatory energy codes that focus on highly efficient and net-zero carbon emissions for new construction within the next decade. Focal areas should include replicable and locally adapted strategies for mitigating heating and cooling demand, such as passive design, shading, natural ventilation, thermal mass, insulation, and low-emissivity windows.

Regulators should develop or expand minimum energy performance standards (MEPS) to set ambitious product energy performance requirements covering all major appliances and systems. MEPS could be especially effective if developed in collaboration across the region to enable cross-border applicability.

Regulatory frameworks to facilitate integrated action

City-level actors should collaborate across sectors and government levels to develop integrated urban planning policies and frameworks that address development patterns, land-use efficiency, transit-oriented design, access to green spaces, resilience and district clean energy planning. Implementing these through collaboration among national, subnational and local agencies will enable urban planning, energy systems and buildings to be more highly integrated, equitable and supportive of growth.

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

National and local agencies should develop clear regulatory and incentive frameworks to promote the use of on-site and building-integrated renewable energy including solar thermal, solar

photovoltaic and advanced biofuels where appropriate. Frameworks should define operational rules, remuneration schemes, incentives allocation, integration mechanisms and goals at national and local levels.

Narratives and engagement to drive demand

National and subnational governments, industry coalitions and civil society should promote the multiple benefits that zero-emission, energy-efficient and resilient buildings have for different stakeholders.

National and subnational governments and large organisations can take leadership in zero-carbon procurement and standards to promote investment in low-carbon building construction and renovation and encourage adoption of efficient technologies at scale.

Governments and industry coalitions should craft narratives that promote good practices such as the use of digital information systems for building operations and energy use, effective data collection, or the use of traditional low-carbon materials with modern construction techniques. Likewise, they can encourage the adoption of digital systems to support greater access to energy services and energy efficiency opportunities.

Capacity building

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

Government and industry coalitions should promote the adoption of existing efficient building construction and operation techniques and low-cost technologies that can improve building performance and lower embodied carbon. These should include sustainable high quality, local materials window and wall shading, and other passive designs.

Building on the Africa Roadmap: Address gaps and raise ambition

Address key information gaps by collecting data and evidence to support actions to decarbonise and improve the efficiency of buildings. Focus should be placed on information needed for integrated and spatial urban planning policies and activities, data collection activities, the participation of the informal sector, building component labelling, building envelopes, the adoption of space cooling systems and heat recovery, the use of life-cycle assessment, material labelling and environmental standards, risk mapping and resilience actions, decentralised renewables deployment, and subsidies. Putting in place systems to capture this information will allow for greater certainty around the impacts that policies and markets are having.










Raise the level of ambition on actions that can support improved building performance and construction methods so that it matches the scale of development change. There is a reported lack of ambition in advancing the use of spatial planning tools and designs, life-cycle analysis, use of shading and improved glazing, building code adoption and compliance, building labelling and benchmarking, and climate resilient building codes.

How to use the regional roadmap document

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

This document identifies common goals, targets and timelines for key actions across eight “activities”. Each activity, outlined in Table 1, represents a segment of the buildings and construction sector: urban planning, new buildings, existing buildings, appliances and systems, building operations, materials, resilience, and clean energy, as each of these represents a key ingredient of how buildings influence our environment and vice versa.

Table 1 • Roadmap definitions

-  **Activity 1: Urban planning.** This activity covers land use, zoning and other planning associated with 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 the operations and management of buildings.
-  **Activity 5: Appliances and systems.** This activity covers lighting, appliance and equipment systems that are used in both new and existing buildings.
-  **Activity 6: Materials.** This activity covers envelope, structural and product materials used in buildings.
-  **Activity 7: Resilience.** This activity covers all aspects of building resilience that enables increased capacity to adapt to and mitigate the effects of changing climates and other natural disasters.
-  **Activity 8: Clean energy.** This activity covers the clean energy transition away from carbon-intensive fuels to renewable energy resources.
-  **Roadmap support: Enablers.** These document the key success factors for capacity building, financial tools and multiple benefits and how they can support the achievement of the targets and timelines for the activities.

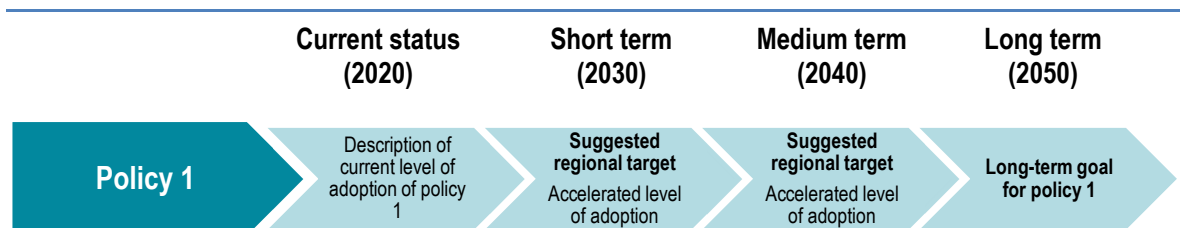
Each of the activities is structured in a similar manner, illustrated by relevant examples, and can be read in isolation or in conjunction with the other parts of the document.

Each of the activities covers:

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

Figure 2, and the paragraph that follows, provide guidance on how to interpret the timelines:

Figure 2 • Demonstration timeline



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

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

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

Stakeholder consultation took the form of questionnaires, in-person workshops, webinars and phone conversations, and included engagement with over 120 people.

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

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

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

These timelines and targets serve to raise ambition and to frame subregional or national roadmap development.

The regional roadmap is a living document for Africa that can be adapted over time to support subregional and local roadmap needs and adapt to trends in the buildings and construction sector.

This roadmap is the product of multiple workshops, webinars, surveying and conversation with experts across Africa, and included the views of over 120 people. The input included: 57 regional stakeholders provided input in-person via two events, 30 responded to the survey, and another 53 participated in webinars.

Introduction

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

The buildings and construction sector is 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 in order to achieve the Paris Agreement goals. Yet the [2019 Global Status Report](#) of the GlobalABC highlights that today's progress on emissions reductions 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.

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

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

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

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

Decarbonising the buildings sector

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

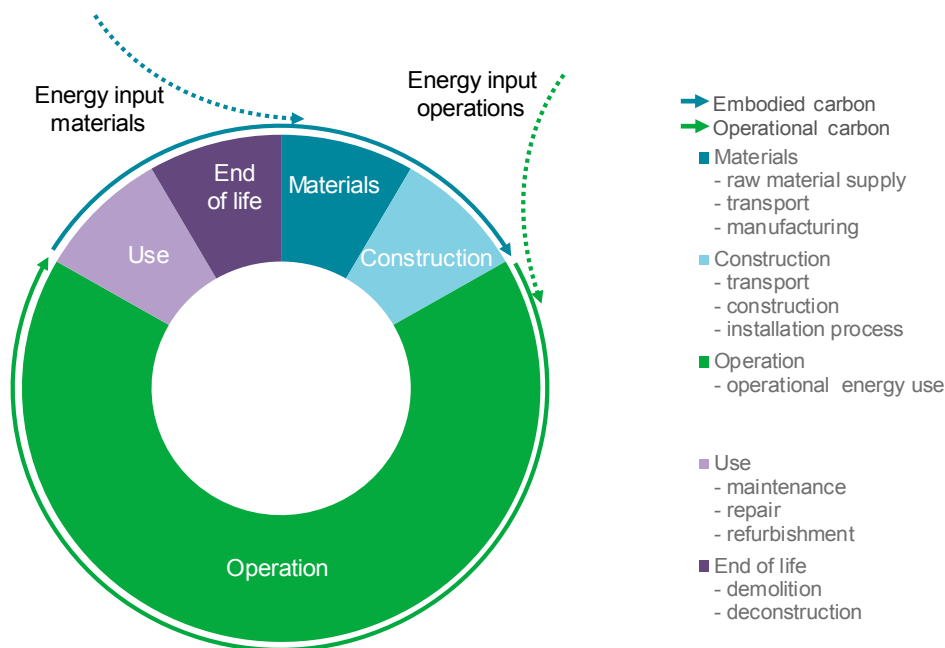
Over its lifetime, a building's carbon footprint consists of the embodied carbon from the manufacture and processing of building materials and construction as well as the operational carbon from their energy consumption. **Whole-life carbon** is described as **operational carbon + embodied carbon**, as calculated over the whole life cycle of the building (Figure 3).

The terms “net-zero energy” and “net-zero carbon” emissions buildings do not have widely recognised standard definitions, and they can be applied to different scopes and site boundaries. However, this roadmap uses the following definitions, based on those described in “Zero energy building definitions and policy activity: An international review” (OECD/IPEEC, 2018):

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

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

Figure 3 • Whole-life carbon: Definitions, adapted from European standard EN 15978



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

Finally, to reach the ultimate goal of whole-life net-zero carbon in buildings, the embodied carbon of building materials must be reduced and offset through low-carbon materials, more efficient manufacturing techniques and the optimisation of materials usage. Indeed, material efficiency strategies could reduce the whole life-cycle emissions of residential buildings by up to 35-40% in Group of Seven (G7) countries³ (IRP, 2020). Increased data collection, labelling, the development of new construction techniques and disclosure of building performance will be essential tools for enabling this transformation at scale, in all regions.

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

³ Estimate for G7 countries.

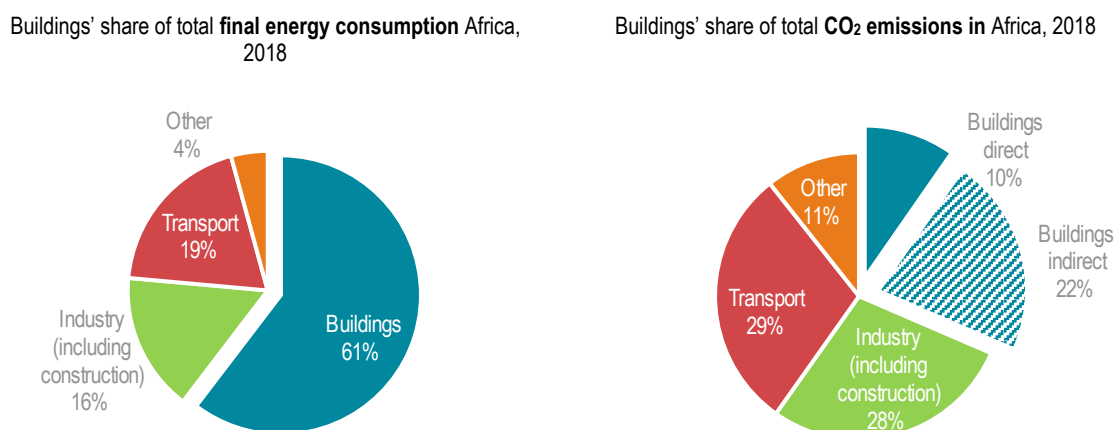
Africa overview

Energy and emissions

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In 2018, buildings accounted for 61% of total final energy consumption in Africa, and 32% of total process-related carbon dioxide (CO₂) emissions, as shown in Figure 4 (IEA, 2019a). When counting the production of construction materials, which accounts for approximately 11% of emissions globally (GlobalABC/IEA/UNEP, 2019), buildings and construction stands out as a key part of the solution to climate change.

Figure 4 • Share of buildings final energy and emissions in Africa, 2018



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

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

Opportunities exist for significant savings in energy and emissions in the buildings and construction sector, while supporting universal access to electricity and clean cooking. These opportunities are illustrated in the IEA SDS.⁴ In the, SDS global CO₂ emissions fall from 33 billion tonnes in 2018 to less than 10 billion tonnes by 2050 and are on track to net-zero emissions by 2070.

In the SDS, emissions from buildings in Africa in 2040 could be up to 300 million tonnes of CO₂ (MtCO₂) per year lower than they are on track to be in the Stated Policies Scenario (STEPS),⁵ as shown below in Figure 5. This significant emissions reduction could be delivered while still supporting growth in gross domestic product (GDP) per capita of over 50% and an almost doubling in floor area. This is equivalent to taking 50 million cars off the roads.⁶ In fact, annual emissions from buildings could even be almost 100 MtCO₂ lower than they are today.

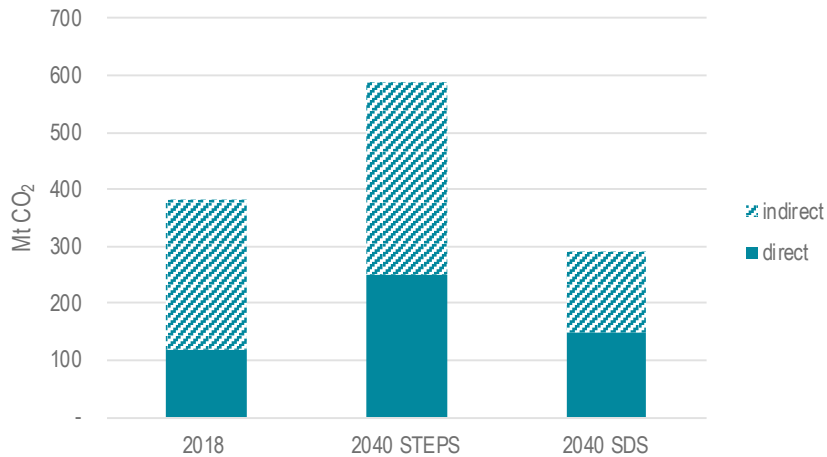
These savings from buildings would contribute to almost half of the total emissions reductions required to get on track with the SDS (IEA, 2019a).

⁴ The SDS holds the temperature rise to below 1.8 °C with a 66% probability without reliance on global net-negative CO₂ emissions; this is equivalent to limiting the temperature rise to 1.65 °C with a 50% probability.

⁵ The STEPS aims to reflect the outcome of all current policies as well as policies that have been announced in targets and plans.

⁶ www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.

Figure 5 • Emissions from buildings in Africa in 2018 and in 2040 under the IEA STEPS and SDS



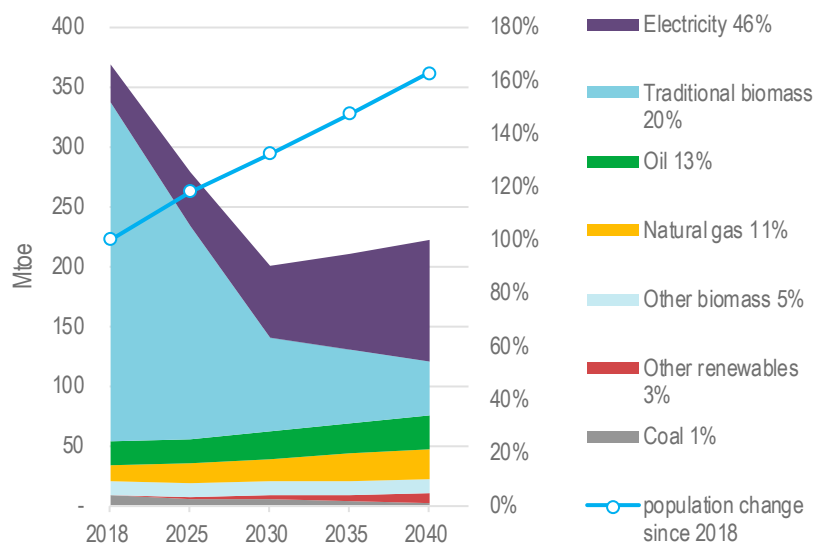
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Notes: Buildings energy use and emissions refers to the operational energy consumption, and does not include the construction phase or the energy and emissions associated with the manufacture of materials. Direct emissions include those from coal,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

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

Increased access to services and a rising population could result in a net rise in direct emissions from today, but still 40% lower than they are currently on track to be. Decarbonisation of the grid and more electrical energy efficiency could deliver reductions of 114 MtCO₂ in annual emissions in Africa compared with 2018, or savings of almost 60% compared with what they are currently on track to be, all while ensuring universal access to energy and clean cooking, and continued trends such as increased floor area and ownership of appliances.

Figure 6 • Energy consumption in buildings in Africa in the SDS



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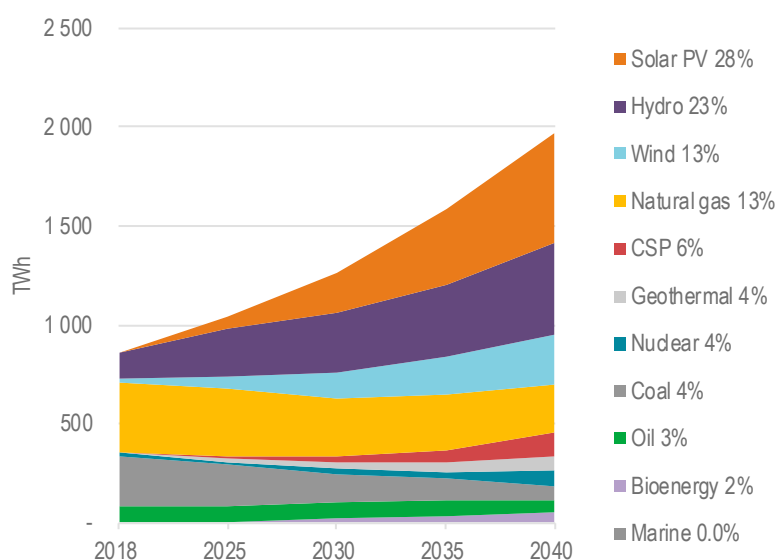
Sources: Adapted from IEA (2019a), *World Energy Outlook 2019* and IEA (2017), *Energy Technology Perspectives 2017*.

In Africa, the energy consumption in buildings in 2018 is largely dominated by traditional biomass for cooking and heating, at 77%, which is expected to be replaced with other fuels in a sharp effort to achieve universal access to clean cooking by 2030, and drop to 20% or 44 million tonnes of oil equivalent (Mtoe) by 2040.

The share of electricity, oil (including liquefied petroleum gas [LPG]) and natural gas are projected grow to 46%, 13% and 11% respectively, as shown above in Figure 6.

With energy efficiency and with the substitution of traditional biomass, the final consumption of energy in buildings in the SDS could decrease by 150 Mtoe in 2040 while almost doubling floor area and providing for 60% more people and increased levels of ownership and use of electrical appliances. Energy intensity will have to improve by 5.5% per year between 2018 and 2030 to reach a reduction in energy intensity in energy per square metre (m²) of 70% as compared with building energy intensity in 2000 (IEA, 2019b).

Figure 7 • The evolution of the electricity generation mix in Africa in the SDS, and % share in 2040



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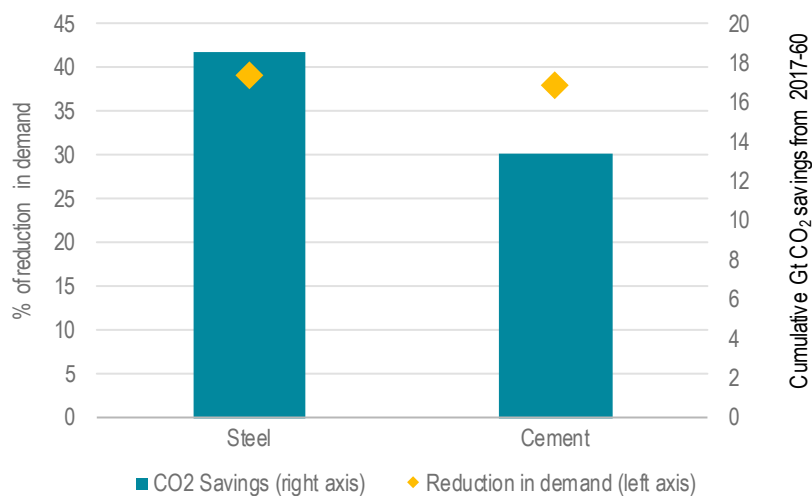
Notes: TWh = terawatt-hour; PV = photovoltaic; CSP = concentrated solar power.

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

As illustrated in Figure 7, electricity from the grid in Africa in 2018 is largely generated through natural gas (40%) and coal (30%), with a 20% share of renewable energy technologies. Under an SDS, by 2040, solar PV, hydro and wind are expected to dominate the generation mix, with a growth of 1% to 28% for solar PV and 2% to 13% for wind, which would make the fuel mix of the grid approximately 75% renewable.

The buildings and construction sector, with its demand for building materials and appliances, is one of the most resource-intensive global value chains and is both a challenge and an opportunity for the region to address carbon emissions. In Africa, there is a lack of data on the potential for emissions reductions from material efficiency at a regional or national level. However, at a global level, with greater material efficiency in design and construction, the demand for steel and cement in buildings in 2060 could be almost 40% lower than in a Reference Scenario (IEA, 2019c) (Figure 8). These reductions could be achieved through optimising building frames and structures, extending the lifetime of buildings, and using best available steel and cement. These are two of the main components of buildings and major sources of CO₂ emissions.

Figure 8 • Possible reductions in material demand and CO₂ emissions reductions in buildings under the Material Efficiency Scenario compared with the Reference Technology Scenario by 2060 (global)



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

The unprecedented rate of urbanisation that is projected to happen in Africa by mid-century will greatly increase the demand for materials. For example, cement production is expected to more than triple in Africa, and steel production would increase more than sixfold (IEA, 2019a). The choices made today are therefore crucial, as they have the potential to lock in embodied and operational emissions for several future decades.

Regional context: Africa

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

Macroeconomic and demographic

The African continent is currently home to 1.2 billion people, which is less than a third of Asia's population (The World Bank, 2019). However, population growth rates in Africa are explosive, making the continent the region with the youngest and fastest-growing population. One in two people born to the global population between today and 2040 is set to be African, and by near the mid-century, the region's population is set to exceed that of both India and the People's Republic of China (hereafter "China") (Espace mondial l'Atlas – SciencesPo, 2019). Over the same period, the continent's urban population is set to grow by more than half a billion, a rate of urbanisation that trumps even that during China's first two decades of economic reform and growth (IEA, 2019d). These unique demographic dynamics frame the context for economic growth, and corresponding demand for housing, appliance ownership and higher levels of building comfort as well as infrastructure and mobility services. The resulting increase in energy demand is not to be underestimated. The buildings sector alone, through increasing demand from appliances, water heating and cooling in residential buildings,⁷ accounted for almost 70% of the increase in electricity demand since 2010 (more than 60 TWh).

Priorities

In Africa, where half of the population lacks access to electricity, ensuring access to energy and clean cooking fuels is of utmost priority for African leaders (IEA, 2019d). Reliability of energy infrastructure is also critical to health, industrial development and economic growth – yet, in 2018, 80% of companies in sub-Saharan Africa suffered frequent electricity disruptions, leading to economic losses.

At the same time, more than 70% of the population (almost a billion people) lacks access to clean cooking. The resulting indoor air pollution from traditional uses of biomass is causing half a million premature deaths per year, while also contributing to forest depletion and loss of productive time collecting fuelwood, which is a burden falling disproportionately on women.

Exploring the region's abundant renewable energy resources and strengthening underdeveloped grids and infrastructure is consequently a top priority. Recent advances in renewable energy technologies and accompanying cost reductions mean that the large-scale deployment of renewable energy now offers a cost-effective path to delivering Africa's inclusive growth ambitions in a sustainable way. In many parts of Africa, decentralised renewable energy technologies offer an economical solution for electrification in remote areas as well as for grid extension.

With increasing energy access and growth, Africa's contribution to global energy-related CO₂ emissions are likely to double from almost 4% today to 7% in 2040 (IEA, 2019a).

While mitigating the contribution from energy-related emissions is an important issue for Africa, an even greater priority is the continent's exposure to climate risk and investing in climate change adaptation. Increased frequency of extreme weather events such as droughts

⁷ The residential sector accounts for around 65% of total final consumption of energy in sub-Saharan Africa (compared with 22% globally and less than 20% in advanced economies), making it the largest end-use sector across sub-Saharan Africa.

and floods are already affecting critical infrastructure, such as power plants and hydropower plants (IEA, 2019d; WEF, 2019). Planning and investment decisions for energy infrastructure thus need to be climate-resilient.

Beyond the energy sector, ecosystems across the continent already suffer disproportionately from climate change, affecting people's livelihood, health and food security. Climate change adaptation is crucial. However, more than 45% of Africa's population is living in countries with the lowest adaptive capacity in the world.

With more than [238 million people in sub-Saharan Africa](#) living in slums or informal settlements, the role of the informal construction sector is an important aspect of future buildings across the region and needs to be addressed when promoting low-carbon building and construction policies and programmes. This is important in terms of including existing bodies of local knowledge about efficient construction techniques and climate as well as sharing new tools and knowledge, while ensuring access to affordable quality materials.

Investment environment

Investment in low-carbon buildings and construction could address both adaptation by providing resilient buildings and urban infrastructure, as well as adaptation through emissions reductions.

So far, Africa accounts for a very small share of global energy sector investment, representing just over 5% of the global total in 2018. Of this USD 100 billion, nearly all went into energy supply, with USD 70 billion invested in fossil fuels, USD 13 billion invested in renewable energy capacity and USD 13 billion invested in electricity networks.

The focus of investments on supply-side infrastructure is missing the multiple benefits that investing in the efficiency of the end-use sectors can deliver for the energy system as a whole, such as contributing to energy access and security by freeing up capacity.

A significant scale-up in investment will be needed thus to unlock the benefits of low-carbon buildings and construction. The International Finance Corporation (IFC) estimates the investment opportunity for green buildings to be around USD 768 billion, most of which is in the residential sector (IFC, 2019).

Policy

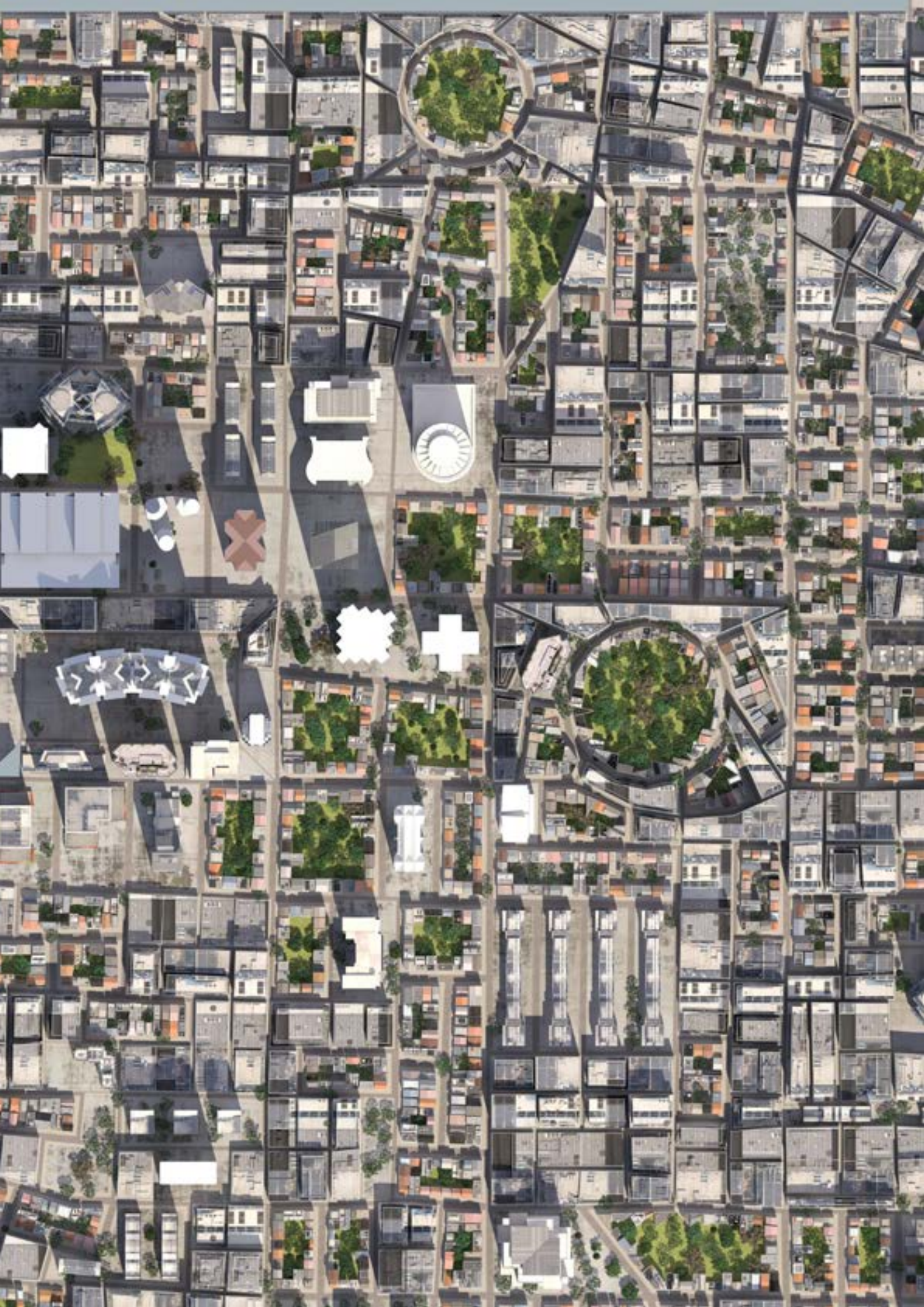
Despite these urgently needed ambitious actions, according to the GlobalABC's [Guide for Incorporating Buildings Actions in NDCs](#) (UNEP, 2018), most NDCs do not include net-zero carbon performance in buildings, or building decarbonisation strategies for that matter. Certain areas such as building design and cooling are included in only a small minority of countries' NDCs. Inclusion of low-carbon materials, reducing embodied carbon and links to urban-scale policies are often missing (UNEP, 2018). Overall, while most African countries mention buildings in some form in their NDCs, the majority do not include defined, ambitious and measurable buildings and construction sector actions (GlobalABC/IEA/UNEP, 2018). Indeed, according to the 2019 *Emissions Gap Report*, many African national and subnational governments are yet to adopt legally binding ambitious targets in the buildings sector, among others (UNEP, 2019).

This is particularly reflected in the extent of building code coverage. In Africa, currently only Morocco and Tunisia have mandatory building codes in place that cover the entire buildings sector. Ghana and Nigeria have codes that cover part of the sector, while Egypt and South Africa have voluntary codes. However, a number of countries are currently in the process of developing building code standards, including Botswana, Burundi, Cameroon, Cote D'Ivoire, Ghana, the Gambia, Kenya, Senegal, Tanzania and Uganda. The remaining 38 countries are yet to implement building energy codes.

Building energy certification involves programmes and policies that evaluate the performance of a building and its energy service systems. Certification may focus on rating a building's operational or expected (notional) energy use, and can be voluntary or mandatory for all or part of a particular buildings sector. As of 2018, approximately 15% of African countries had adopted building energy performance certification programmes; however, only South Africa has a widespread certification

Many countries within Africa have reported an NDC, which is the process by which countries announce their national-level commitments to reduce carbon emissions. To date, most African countries (68%) mention buildings, although most NDCs still do not include explicit actions to address buildings sector energy use and emissions. This roadmap aims to support governments in their NDC development by providing an illustration of the pathway towards a zero-emission, efficient and resilient building stock.

With rising demand for appliance ownership, especially for cooling appliances due to increasing incomes and living standards, more widespread adoption of minimum energy performance standards (MEPS) will be crucial. The continent and its respective subregional economic communities could benefit from exploring harmonisation and co-operation in setting up new MEPS programmes as well as expanding and strengthening existing ones.



Targets and timelines

Activity 1: Urban planning

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

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

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

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

In the coming decades, with increasing linkages between urban planning and its impact on energy use and emissions from buildings and transport, urban planning policies can play a significant role in embedding energy efficiency in spatial planning to support the transition towards zero-emission, efficient and resilient urban form, buildings and construction. The trends and challenges for urban planning in Africa are explored in Box 1.

Box 1 • Urban planning in Africa: Trends and challenges

Africa has the world’s fastest-growing population. Half of world population growth in the period to 2040 will happen in Africa (IEA, 2019d). The urban population in sub-Saharan Africa is growing rapidly, and has more than doubled since 2000 to reach 440 million today. The share of the population living in cities is now 40%, up from 32% in 2000 (IEA, 2019d). Urbanisation of this scale and pace is unprecedented, and is expected to be twice as large as the projected growth of India’s urban population in India by 2040 (IEA, 2019d).

Africa is currently home to three megacities: Kinshasa, Lagos and Cairo. There are another five large cities on the continent with a population of between 5 million and 10 million each: Alexandria, Dar es Salaam, Johannesburg, Khartoum and Luanda (UN-DESA, 2018). Of these, Dar es Salaam and Luanda are likely to become sub-Saharan

Africa's next megacities. The implications of this rapid urbanisation for urban energy demand in the next two decades are powerful, in terms of health, environment and economic growth.

As a growing proportion of the African population moves to cities in the period to 2040, demand for energy services will also grow. The average urban household consumes three times more oil and electricity than the average rural household in sub-Saharan Africa (excluding South Africa) (IEA, 2019d), although there are large disparities within and across cities.

A large share of the migration to cities is made up of low or unskilled labourers from rural areas – often moving to peri-urban areas which are home to 55% of the urban population in sub-Saharan Africa today (Odarno, 2019). In these areas, electricity access rates are lower than in city centres, with more than 100 million urban Africans living underneath an electricity grid without an electricity connection (Odarno, 2019).

Most energy in sub-Saharan Africa (excluding South Africa) is used for cooking, which accounts for around 70% of total final consumption, compared with less than 10% globally. Charcoal and firewood remain the predominant cooking fuels in many peri-urban households (IEA, 2019d). Globally, nearly 2.4 billion people continue to use inefficient open fires or simple cook stoves today, around 840 million of whom live in sub-Saharan Africa (excluding South Africa). To date, cleaner processed forms of bioenergy such as biogas and biofuels have made limited progress in the region (IEA, 2019d).

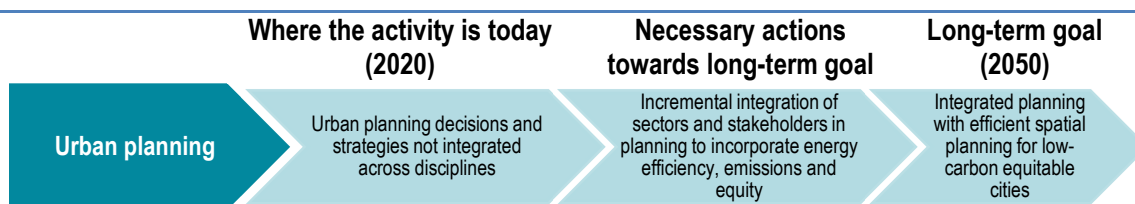
Sub-Saharan Africa (excluding South Africa) has the world's lowest per capita car ownership level. It has a smaller passenger car stock than Australia, whose population is 95% smaller. The projections for Africa show a large expansion of the passenger car stock in the period to 2040. According to current trends, the car fleet in 2040 in sub-Saharan Africa (excluding South Africa) triples to reach 27 million, but this still means average ownership levels of only 15 cars per 1 000 people, equivalent to 60% of the rate in India today. Factoring in an accelerated rate of economic growth, the car fleet could reach more than 35 million (IEA, 2019d).

Although the scenario is challenging, this rapid urbanisation represents an opportunity for African countries and cities to enhance their planned urban development and set them on low-carbon growth pathways in areas of spatial design, energy, buildings, services and transport (United Nations, 2017).

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

Key actions for urban planning

Figure 9 • Key actions for urban planning in Africa



Key actions for urban planning include:

- **Integrated urban planning policies.** Cities are complex and dynamic systems. As such, urban planning policies can achieve maximum impact when they are systemic and integrated rather than isolated and sectoral. Enacting urban planning policies on national and local levels that take into account the multifaceted nature is central to ensuring the decarbonisation of buildings and construction, with a priority for those cities experiencing the highest and fastest population growth. Involve citizens and encourage their active participation in the planning process so as to improve their understanding of urban issues and foster knowledge sharing.
- **Local and national urban plans underpinned by location efficiency.** National and local policies can play a key role in promoting compact and efficient urban forms. These plans should increasingly include rules for location efficiency, transit-oriented design (TOD), mitigation of the heat island effect, zero-carbon building codes and resilience.
- **Institutional co-ordination.** Ensure collaboration and co-ordination among national, provincial and city levels, and across disciplines including transport, spatial planning, social housing and energy supply, based on good communication and awareness of the multiple benefits of decarbonising buildings and construction.
- **Skill development and professional training.** Urban planning and urban design training as a discipline is a key aspect of developing capacity to develop integrated urban planning across different land-use challenges, social and cultural practices, development and economic objectives, environmental sustainability, and design approaches. Developing courses and professional bodies and accreditations in urban planning will help to improve integrated urban planning.
- **Data collection.** The collection of robust urban energy statistics is central to identifying and prioritising major contributors to energy use and emissions. By investing in data collection, processing and analysis as well as streamlining data collection methods and systems across relevant stakeholder groups, national and local governments will be able to monitor progress towards national and local energy and climate goals. This will also enable benchmarking across sectors and levels.

Stakeholders for urban planning

By nature, robust municipal plans draw in all key stakeholders, so they come to understand different urban pressures and priorities and foster agreement on the acceptable trade-offs (Gencer, Hardoy and Winograd, 2018). In Africa, the key stakeholders for sustainable urban planning include those that can influence urban planning and those that can deliver the results of zero-emission, efficient and resilient buildings through urban planning. Additional stakeholders include those that can support the process through research, funding, training and making technologies available.

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

Table 2 • Stakeholder mapping for urban planning in Africa

National government	Subnational government	Utility companies	Property and project developers	Financial institutions	Architects and engineers	Manufacturers, retailers and suppliers*	Labourers and installers	Building owners and occupants	Civil society**

* of appliances and materials.

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

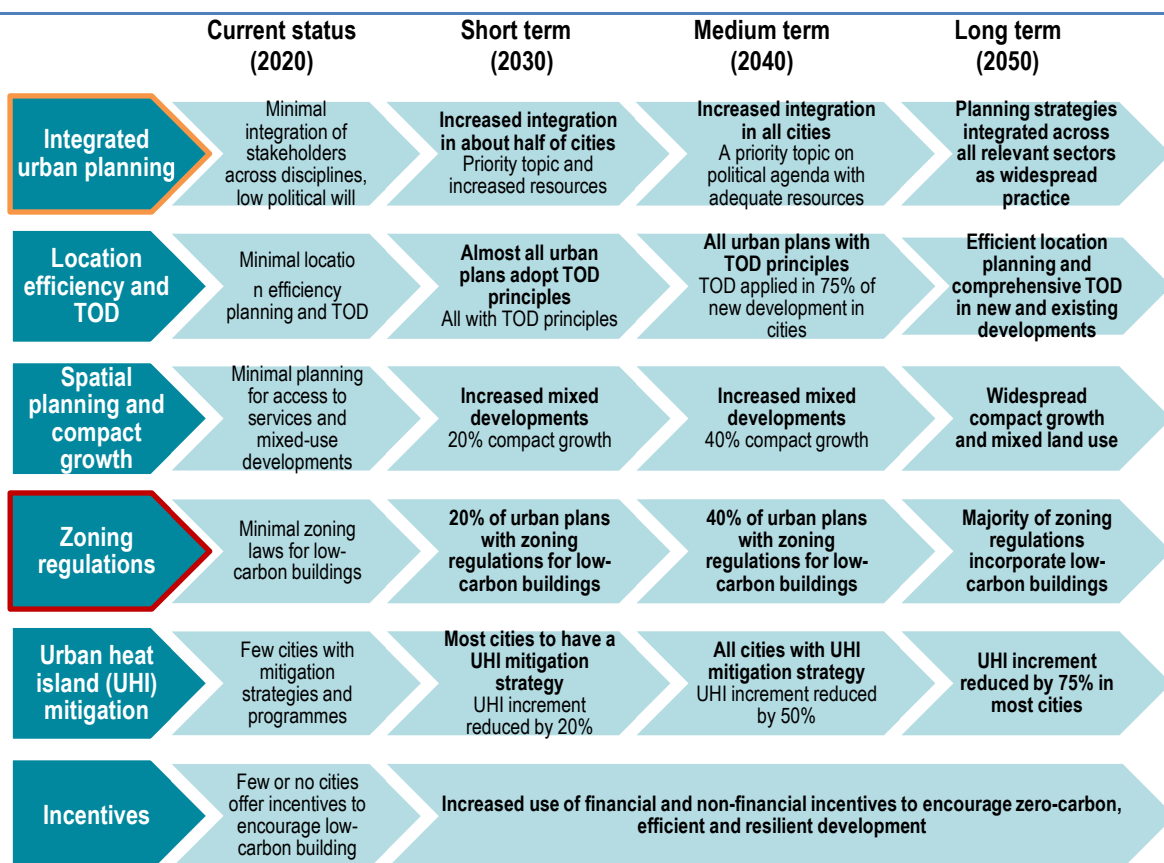
Note: The darker the colour, the higher the impact that stakeholder group has on the activity and the more essential it is to delivering the roadmap targets.

Policy for urban planning

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

The sub-targets and timelines in Figure 10 offer more details:

Figure 10 • Policy timelines for urban planning in Africa



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

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

- **[data gap] Integrated urban planning:** Integrated urban planning creates a formal framework to encompass multidisciplinary issues, such as climate change, disaster risk reduction and emergency response, as well as land use and transport, location of services and infrastructure, and social housing. A critical aspect of delivering this planning framework is the articulation of a clear city vision. Institutional co-ordination can start with the ministries in charge of land use, transportation, buildings, and energy and environment, and progressively integrate more sectors as priority areas are defined (e.g. health, water and sanitation, waste, education, public parks). The development of a shared and integrated city vision requires alignment among different levels of government and across the motivations of different stakeholders involved in designing and implementing projects at the city level. Integrated planning is therefore underpinned by active and ongoing processes of communication and co-ordination at all stages of planning. Such integration can help to mainstream energy efficiency strategies across all departments of local governments. As well as integrated, urban planning strategies must be incremental. Seventy percent of Africa's urban population lives in informal settlements and 60% of total urban employment is in the informal economy (The World Bank, 2013). Incremental urban planning is based on the recognition that upgrading and incorporating informal settlements into the formal fabric is a key vision for shaping a wealthier and more resilient African urban landscape and should be seen as part of the integrated development strategy.
- **Location efficiency and TOD:** There is growing consensus on the importance of strategically integrating urban infrastructure and land-use planning to achieve zero-carbon emissions, efficiency and resilience goals. Urban form is a key determinant of travel behaviour. Housing location decisions have a huge impact on overall energy use and emissions. Households can reduce their transportation-related energy use by opting for compact, mixed-use communities that are "location efficient", i.e. accessible through multiple modes of active and public transportation (EPA, 2011). The majority of location efficiency strategies are controlled by local government authorities. Zoning regulations that support location efficiency promote mixed-use zones, adjust zoning standards to allow compact urban development, raise the threshold of building density in urban cores and around transit nodes that can support denser development, encourage walkable communities, and designate strategic growth areas to direct urban expansion and property development (IRP, 2018). Zoning mechanisms to promote location efficiency include the use of overlays that add transit-related and density requirements to existing codes (ACEEE, 2019). *Stakeholder feedback: There was strong consensus that transit accessibility could be fully incorporated into urban plans by 2030.*
- **Spatial planning and compact urban growth:** 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 energy use and emissions from avoidable transport and to enhance quality of life. Compact urban configurations can improve living conditions of urban residents through: spatial restructuring of the urban form to achieve "strategic intensification" (IRP, 2018); human-scale design that creates socially mixed neighbourhoods, with a diverse mix of housing types and social functions, and

strengthen access to employment opportunities near residential areas; and sustainable mobility options such as light rail and bus rapid transit systems, bike lanes, and overall walkability (IRP, 2018). *Stakeholder feedback: Several respondents cited the containment of urban sprawl as a key challenge for urban planning design.*

- **[ambition gap] Zoning regulations for low-energy and low-carbon buildings and communities:** Local jurisdictions have an important role to play in integrating energy-related requirements into zoning regulations and streamlined “form-based” codes that increasingly link urban planning to sustainable buildings and communities not only in terms of controls on density and land use, but also in terms of the physical form of the built environment. The objective is to create a specific type of urban fabric, which promotes low-resource, compact, walkable and community-driven cities. For example, form-based codes can promote shared parking, integrated storm-water run-off solutions, quiet and clean spaces to allow for natural ventilation strategies to be used, or shared solar PV rooftop installations. These approaches can promote efficient systems by maximising synergies between highly efficient buildings and renewable energy sources and demand response. This initially could include special zoning districts that require increased sustainability and expand over time to include all zoning districts. *Stakeholder feedback: Consensus from local stakeholders was that “few” to “about half” of cities would succeed in implementing zoning regulations for low-energy and -carbon buildings, mainly due to lack of political will, capacity and conflicting influence of the private sector.*
- **UHI:** Un-vegetated, impermeable, and dark surfaces in cities tend to generate UHI effects, i.e. higher ambient temperatures. Buildings, parking lots and paved surfaces absorb more heat than moist, vegetated surfaces, which release water vapour and provide shade to cool the surrounding air. Consequently, the annual mean air temperature of a city with at least 1 million people can be up to 3°C warmer than surrounding rural areas (EPA, n.d.). These temperature increases will add to the warming that cities are experiencing from climate change. To minimise this effect and mitigate extreme heat events, cities are establishing goals for UHI reduction and implementing a variety of programmes and policies. Local authorities may aim at reductions in impermeable surface areas, increases in the tree canopy, deployment of cool or green roofs and facades, or the expansion of wetlands. Quantitative goals should be included in formal city plans and specify a future target date or annual commitment (ACEEE, 2019). *Stakeholder feedback: Strategies for mitigating the UHI effect in cities is largely absent from urban planning strategies currently, and there was strong consensus that this would be implemented only by 2040.*
- **Incentives:** Financial and non-financial incentives such as tax rebates, expedited permitting, density bonuses or increased project scope can be used by cities to encourage development that is in line with the aim of reaching zero-carbon, efficient and resilient buildings and cities. *Stakeholder feedback: There was consensus that the use of incentives is currently very limited across the region, but they were important tools and would increase to be widespread by 2050.*

Box 2 • Regional examples of action on urban planning policy

Integrated development plans in South Africa

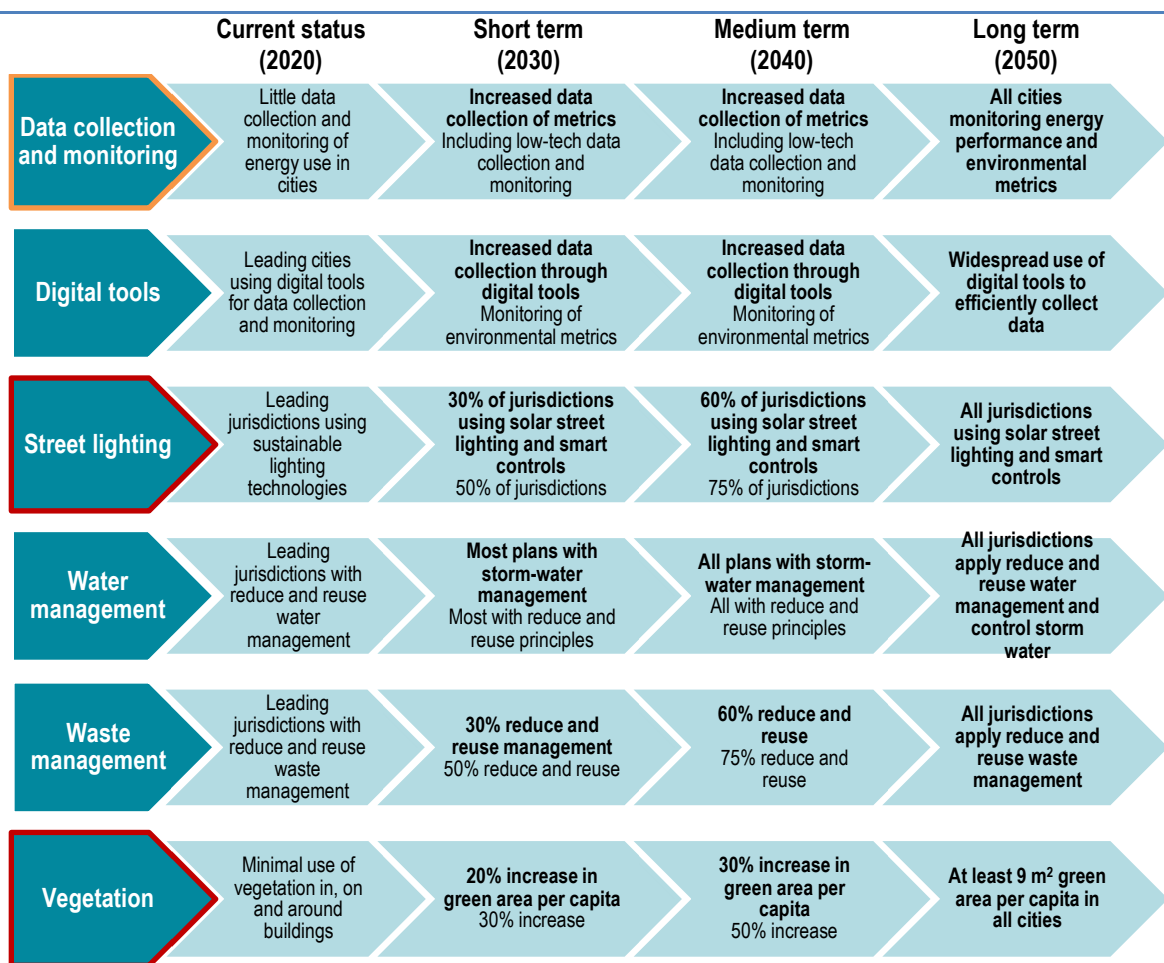
Integrated development plans (IDPs) are the most important planning documents for South African municipalities. Through its IDP, a municipality identifies development priorities; formulates a vision, objectives and strategies; identifies projects; and aligns resources with priorities (SALGA, 2015).

Based on an analysis of the IDPs published in 2017 of the 205 South African local municipalities, 44 district municipalities and 8 metros, street-lighting projects were the most prevalent intervention in the field of energy efficiency. Street lighting usually accounts for between 15% and 30% of total energy consumption within South African municipalities' operations. It is one of the easiest energy efficiency intervention areas with approximately 20% electricity savings potential. Most of the common technical measures applied to address energy efficiency in street lighting can generate between 38% to 54% energy savings per measure, and these have very short payback periods (SALGA, 2015).

Technology for urban planning

Technology can enable increased action towards zero-emission, efficient and resilient buildings when coupled with urban planning. Specific targets and timelines for sustainable urban planning technologies are outlined in Figure 11:

Figure 11 • Technology timelines for urban planning in Africa



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

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

- **[data gap] Data collection and monitoring:** Improved access to data helps cities measure, monitor and manage energy use and environmental impacts. Regular tracking of energy-related metrics allows cities to set a benchmark for energy usage and target specific areas where savings can be quickly achieved (ACEEE, 2019). Local government authorities should collect energy data covering public buildings and infrastructure, private buildings, and transportation, linking to existing databases (e.g. property registers). This would enable them to make the case for priority interventions and evaluate the effectiveness of existing policies over time. In turn, this data would help to communicate the importance of resilient and low-carbon buildings through evidence-based analysis and gain the support of local citizens and relevant stakeholders. The use of PPGIS (public participation geographic information system) can promote empowerment and ensure the inclusion of people who otherwise have little voice in the public arena. PPGIS can work as a bridge between the experts traditionally involved in urban planning and the participatory planning that draws on the local expertise (Brown, 2012).
- **Digital tools:** Support the increased use of tools that use data and information, such as geographic information system (GIS) mapping, satellite images, cost data, benefits analysis and life-cycle analysis (LCA) to make science-based decisions in the urban planning process. While there is no commonly agreed definition, the emerging definition of smart cities is that they are monitored through information and communication technology and digital technologies, with the goal of using “enhanced real-time data, automated utility systems and digital communication tools to increase the provision of urban services (e.g. transport, energy, water) and governance in a way that is cost-effective and accountable” (OECD, 2016). Smart-city applications include among others: smart streetlights, building management systems (BMS), smart electric grids, and intelligent traffic and transit solutions. Smart solutions may also offer valuable applications to enhance the resilience of the built environment in particular to climate impacts, as discussed in the “Resilience” section. *Stakeholder feedback: There was strong consensus that few to no jurisdictions use digital tools in urban planning decision-making, but it is expected that their use will become widespread by 2050.*
- **[ambition gap] Street lighting:** Support the switch to smart and efficient lighting, including promoting solar street-lighting technologies on the exterior of buildings and streets where relevant and effective on a whole-life-cycle basis. Smart lighting, which includes sensors and controls, can be integrated with other environmental and site condition information, such as traffic. Appropriate measures should be taken to minimise impact on population health and biodiversity by using appropriate light diffusion devices and lighting schedules. Street lighting typically represents 5% or more of cities’ annual operational budgets, especially in resource-constrained cities, and can therefore generate significant savings, while better quality and extension of street lighting can also contribute to crime reduction at night. *Stakeholder feedback: Apart from Rwanda, which already has adopted smart street lighting, the adoption of smart systems for street lighting appears to be limited. It is expected that most jurisdictions will adopt these systems by 2050.*

- Water management:** Support the increased use of water management technologies that reduce water run-off and increase landscape permeability and rainwater retention. This can support resilience against floods and improved health of soil and underground aquifers. *Stakeholder feedback: There was consensus that storm-water management is currently not incorporated into urban plans, but that it could be fully incorporated by 2030 to 2040. The exception was Rwanda, which already appears to incorporate water management in its urban plans.*
- Waste management:** Support the increased use of waste and wastewater storage and treatment technologies that can reduce energy use for waste from buildings. Waste management is one of the core functions of city authorities but remains a crucial challenge in many cities across the world, often representing 20-50% of municipal annual budgets (The World Bank, 2018). In addition, waste generated in informal settlements is often dumped into local streams and drainage canals, exacerbating flooding risks. *Stakeholder feedback: Waste management policies appear to be limited, and there was consensus that they may be incorporated by 2030 to 2040. The exception was Rwanda, which already incorporates waste management in its urban plans.*
- [ambition gap] Vegetation:** Landscaping and vegetation can support improved resilience to excess storm water and reduced need for heating and cooling through measures such as green roofs, green walls, trees and parks. In particular, urban parks are critical in improving urban quality of life, in cooling cities, and in acting as a sink for greenhouse gas (GHG) emissions. However, with few exceptions, most cities in Africa do not meet the World Health Organization’s recommendation of 9 m² of green space per urban dweller. Consequently, many cities are actively engaged in recovering fringe areas such as wetlands or refurbishing parks that have fallen into disrepair, and developing green spaces through linear parks and urban reforestation initiatives. Vegetation measures should prioritise the use of indigenous plant species. *Stakeholder feedback: Currently, urban ecology has been included to some extent in urban planning strategies in the region, and there was strong consensus it would be fully integrated across the regions by 2040. The exception was Rwanda, which already incorporates vegetation in its urban plans.*

Box 3 • Regional examples of action on urban planning technology

Street lighting

All cities have some degree of control over outdoor street lighting. Public lighting can consume as much as 40% of a city’s energy budget – this is the case in major Moroccan cities, for example (Challenge, 2016). Local governments can take a proactive role by providing the funding and managing the procurement, installation and oversight of lights. In Zimbabwe, the local board of Hwange is self-funding the installation of a pilot project of 100 solar streetlights, worth around USD 300 000. This has two objectives: reducing the crime rate and the level of electricity bills. The board aims to raise funds through taxation to eventually replace all existing streetlights (IRENA, 2016).

Regional

Many countries across Africa face the challenge of collecting and accessing timely and accurate data. For example, 14 African countries are taking on this challenge, notably by adopting open data policies through initiatives such as the [Open Government Partnership](#), which provides policy frameworks for public access to data. A few local governments such as [Sekondi-Takoradi, Ghana](#); [Elgeyo Marakwet, Kenya](#); [Kaduna State, Nigeria](#); and [Kigoma-Ujiji, Tanzania](#), are also adopting some of these policies. The online platforms that allow public access to data are also internally beneficial in improving access to data within these governments.

Kenya

Another example of collaborative and community-led digital mapping such as [OpenStreetMap](#) and Spatial Collective is MapKibera, which bring together several communities to participate in the mapping of informal settlements, with a view to gain access to emergency services, as well as advocate for basic service delivery such as water, sanitation

and roads. With technical support from local or international partners, communities use satellite imagery and field surveys together to plan and advocate for slum improvement. Very high-resolution images from Google Earth are used to digitise slum boundaries and attach information on households, dwellings and site characteristics from field surveys collected by slum residents.

Spatial and socio-economic data are then entered into a GIS database and accessed by the community to prepare upgrading plans. When demographic information is overlaid on new maps, it can help government officials identify the areas in greatest need for services and initiate city planning to improve slum settlements by widening roads, installing flood protection and building new infrastructure (Blakemore, 2016).

Finance for urban planning

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

Financial tools particularly relevant to urban planning include:

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

Capacity building for urban planning

Information combined with capacity-building activities can increase overall awareness, improve the decision-making process and encourage more sustainable choices. Training for professionals

working directly with the built environment can enable increased resources and capacity to deliver sustainable urban planning.

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

Table 3 • Capacity building for urban planning in Africa

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

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

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

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


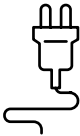


Further details regarding capacity-building activities are provided in the section “Roadmap support: Enablers”.

Multiple benefits of sustainable urban planning

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

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

Table 4 • Multiple benefits of urban planning

Environment	
	<ul style="list-style-type: none">• Emissions reductions – sustainable urban planning delivers emissions reductions through the reductions in emissions from transport thanks to TOD and encouraging walking and cycling, and absorption of CO₂ through open green spaces.• Air quality – sustainable urban planning reduces air pollution through the reduction of transport-related emissions through TOD, open green spaces, and encouraging walking and cycling.
Energy	
	<ul style="list-style-type: none">• Energy savings – sustainable urban planning through mixed-use developments and TOD reduces commutes and supports mass transit, walking and cycling.• Energy security – sustainable urban planning delivers buildings, cities and transport systems that put less strain on energy systems by reducing energy demand and favouring local renewable energy sources.• Energy prices – sustainable urban planning supports integrated buildings, transit and energy systems that optimise potential synergies and energy flows to reduce energy demand and peak loads, lowering network infrastructure and system costs.
Economy	
	<ul style="list-style-type: none">• Productivity – sustainable urban planning increases the efficiency of the urban infrastructure and enables increased productivity through reduced commuting times, also improving health and well-being.• Asset value – sustainable urban planning can increase the asset value of homes, businesses and transit systems by saving time and money and creating more liveable cities.
Society	
	<ul style="list-style-type: none">• Poverty alleviation – sustainable urban planning reduces building operation and transport costs, and can deliver improved access to employment and other services for vulnerable populations.• Health and well-being – sustainable urban planning can support increased physical and mental health through improved access to employment and transit, greater use of active modes for commuting (walking, biking), reduced air and noise pollution, reduced time spent in transport, green spaces, and other amenities.• Safety and security – sustainable urban planning by mixed-use and transit-oriented planning can support improved social integration and urban lighting, enhancing safety and security.



Activity 2: New buildings

This section addresses measures to reduce the operational energy (and consequently, operational carbon) in new buildings. Integrated policies for new buildings can avoid locking in emissions from inefficient buildings for multiple decades. Fully decarbonising buildings over their whole life cycle will also require measures to reduce the embodied carbon of materials, addressed in “Activity 6: Materials”, and measures to increase the share of renewable energy, both in distributed generation and in the electricity sector, as described in “Activity 8: Clean Energy”. Box 4 highlights a number of trends and challenges for new buildings in Africa.

Box 4 • New buildings in Africa: Trends and challenges

Floor area in Africa is expected to double between now and 2050, over 90% of which will be in the residential sector (IEA, 2017).

Morocco and Tunisia are the only countries on the African continent to have mandatory building codes that cover the entire buildings sector. Rwanda has a mandatory code for commercial buildings, while South Africa, Nigeria and Egypt have developed voluntary codes. A number of countries are in the process of developing building code standards, including Botswana, Burundi, Cameroon, Cote D'Ivoire, Ghana, the Gambia, Kenya, Senegal, Tanzania and Uganda. The remaining 38 are yet to implement building energy codes (GlobalABC/IEA/UNEP, 2019).

The main barrier today is the perception of high capital costs that efficient building will require in countries where population has few resources.

Africa is the home of countries with very hot climates, with the current populations not having access to cooling. The demographic growth and climate change will put strong pressure on the region's cooling needs. Demand for active cooling (air conditioning and other forms of mechanical cooling) is growing, highlighting the importance of thermal performance and design standards to ensure comfort with the help of passive cooling.

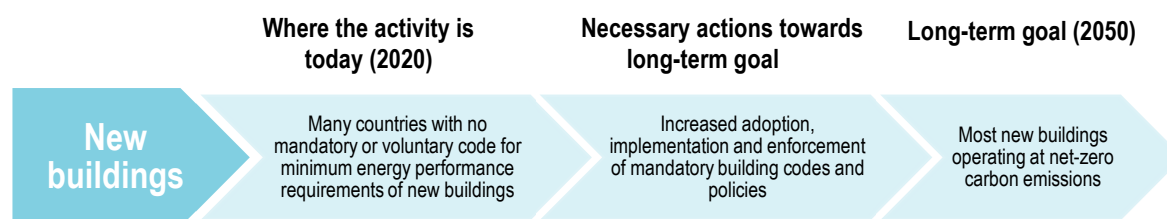
African cities will continue to experience high growth, with an additional 580 million additional people expected to be living in urban areas by 2040 (IEA, 2019d). This means high construction rates will increase, elevating the need to ensure that new buildings are built to a high performance standard. Eighty percent of buildings needed by 2050 have not been built yet. Building codes also play an important role in the construction industry. These codes require countries to establish regulatory frameworks to set performance standards and ensure compliance with them.

Increasing population growth will increase the demand for housing, and in particular social housing. A particular challenge for the region will be delivering quality housing that is affordable to both the government budget and to the final building occupant.

The role of the informal construction sector is high, and this segment of the sector must be included to ensure equity and inclusion. Capacity building and the increased affordability and availability of quality materials and tools will be key to achieve this.

Key actions for sustainable new buildings

Figure 12 • Key actions for new buildings in Africa



A series of key actions will be needed to achieve sustainable, zero-emission, efficient and resilient new buildings:

- **Develop a roadmap strategy.** Develop a locally appropriate strategy for decarbonising buildings using an efficiency-first approach, and whole-life-cycle carbon assessment approach, including a strategy for decarbonising construction materials and energy aiming to reach net-zero carbon buildings by 2030.
- **Develop and implement mandatory energy codes.** Transition from voluntary to mandatory codes that set the minimal efficiency in all new buildings. Ensure that adequate capacity and tools are in place to enable compliance across the buildings sector.
- **Strengthen building energy codes.** Ensure that there is a building code improvement cycle that strengthens the performance requirements every three to five years with aspirations of achieving zero emission and net-zero-energy buildings. Integrate building codes with resilience, materials and urban planning strategies.
- **Avoid the need for space conditioning.** While the region is warm, vernacular architecture has traditionally avoided the need for space cooling. Good passive design should be prioritised to ensure new buildings avoid the need for active space cooling systems.
- **Enable sustainable building investments.** Enable increasing design and construction of sustainable buildings by increasing access to and use of finance to enable private investment.
- **Governments lead by example.** Develop policies that ensure all new government buildings are low-emission and efficient; promote demonstration or pilot projects to illustrate best practice.
- **Reduce embodied carbon** through materials measures (see “Activity 6: Materials”) and reduce operational carbon through better operation and maintenance (O&M) (see “Activity 4: Operations”) and increase the share of clean energy (see “Activity 8: Clean Energy”).
- **Increase the use of building design tools.** More integrated design processes and simulation or modelling tools such as BIM (building information modelling) can help ensure higher performance in a cost-effective manner.
- **Increase awareness and information.** Awareness of the benefits of more sustainable buildings will enable consumers to make better choices, and can enable more advantageous financing.

Stakeholders for sustainable new buildings

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

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

Table 5 • Stakeholder mapping for new buildings in Africa

National government	Subnational government	Utility companies	Property and project developers	Financial institutions	Architects and engineers	Manufacturers, retailers and suppliers*	Labourers and installers	Building owners and occupants	Civil society**

* of appliances and materials

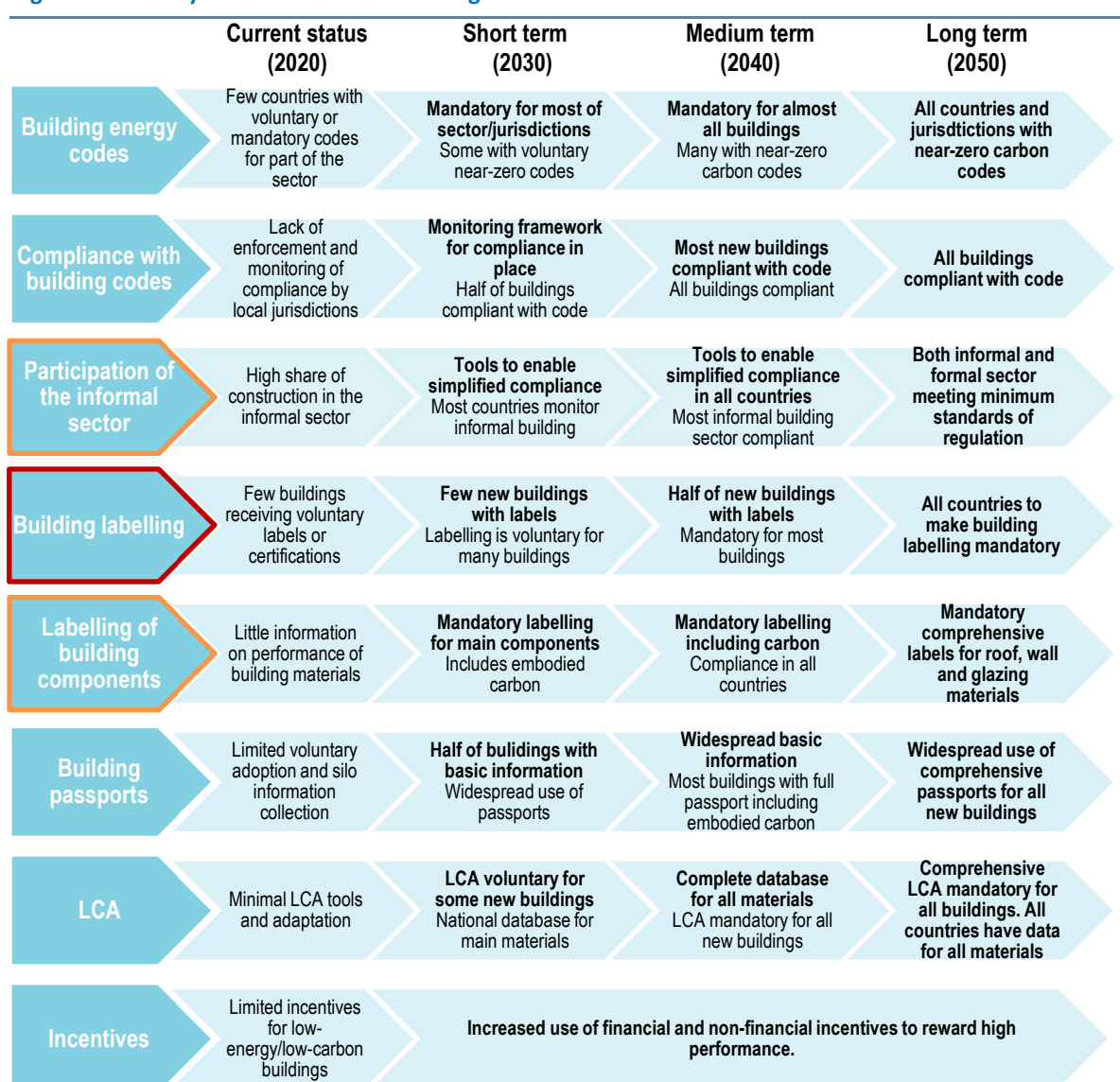
** including academia, NGOs, research institutions, social networks and community associations.

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

Policy for sustainable new buildings

The policies listed in the timelines in Figure 13 represent key tools that policy makers have at their disposal to increase the performance of the new buildings that are built, to reach zero-emission, efficient and resilient buildings as soon as possible. These policies are applicable at both national and subnational levels, and will need to be supported by enabling policies and programmes as detailed in the subsections below.

Figure 13 • Policy timelines for new buildings in Africa



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

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

- **Building energy codes:** Building energy codes or standards provide minimum requirements for building components or for building performance that can enable zero-emission, efficient and resilient new buildings. Building codes should be mandatory and cover all types of building, and be based on a whole-lifecycle carbon approach (including operational carbon and embodied carbon). These aim towards net-zero emission buildings at lowest cost by ensuring highest efficiency levels first. Building codes should include, or refer to, locally adapted bioclimatic design principles to optimise passive design, and be linked to occupancy or building permits to be most effective. The first building codes should be prescriptive in format, evolving into performance-based codes. Specific standards, guidelines and tools for social housing and the informal sector can be used to facilitate compliance within this sector. More information on building codes can be found in Box 5. *Stakeholder feedback: There was strong consensus that requirements for net-zero buildings would be achievable from 2030 and mandatory for all new buildings by 2050.*
- **Building energy code compliance:** Compliance with, and enforcement of, building codes is crucial yet challenging, as it is often up to subnational governments to enforce, despite variations in human and financial resources. A monitoring framework for compliance checking, accessible tools and extensive capacity building will facilitate compliance and even enable compliance within sectors such as the informal sector and the social housing sector. *Stakeholder feedback: Across the region, there was a view that most buildings could achieve full compliance by 2040 and 2050.*
- **[data gap] Participation of the informal sector:** Capacity building, accessible construction guidelines and tools, and wide stakeholder engagement will be key to increase the compliance with codes within the informal building sector. *Stakeholder feedback: The high participation of the informal construction sector was raised by several respondents as a key barrier.*
- **[ambition gap] Building labelling:** Quantitative building energy labelling can be used to assess “as designed” building performance on a scale of less to more efficient. Labelling enables increased information sharing and awareness for consumers and investors. Labelling can also be linked to incentives and financial tools. Certification such as green building certification is included in this policy as another form of assessing performance. Labelling and certification systems should be continually monitored and revised to ensure the top rating is truly reserved to the top performing buildings of the market. *Stakeholder feedback: There was no strong consensus that labelling will become widespread by 2040 or 2050 for “most” to “all buildings”.*
- **[data gap] Labelling of building components:** The availability of robust performance information of individual building components and materials is key for designers to optimise building design, and perform robust LCA based on whole-life performance. Key performance parameters include the thermal transmittance of materials, the solar heat gain coefficient (SHGC) or solar factor of glazing, and the reflectance of surface finishes. Additional information should eventually include embodied carbon, particularly for materials whose embodied carbon can be significant (insulation, glazing, window frames).
- **Building passports:**⁸ Building passports can be used to track information about the building, materials, systems, energy use, renovations and other real estate information to improve decision-making processes. At the time of handover of a new building, a new building passport could include floor area schedules, bill of quantities, embodied energy of materials,

⁸ A building passport is a document or logbook that is used to store and track information about the building: basic characteristics, materials, systems, energy use, renovations and other building information.

description of systems, maintenance schedules and estimated energy consumption. During its operational phase, it may be completed with further information (see “Activity 4: Building operations”). *Stakeholder feedback: There was little consensus across the region as to when building passports might become widespread, though it was thought that around half could be achieved by 2050. The content of the passports should include bill of materials, embodied energy, description of systems and maintenance schedules now and by 2030.*

- **[ambition gap] LCA:** Decisions regarding the building use, design and choice of materials should consider the entire lifetime of the building and its components. National databases containing information on the embodied energy and carbon of construction materials will be necessary to undertake comprehensive life-cycle impact analysis of design choices. *Stakeholder feedback: Few tools to enable robust LCA are available today and there was no agreement for when buildings would make use of these tools.*
- **Incentives:** Fiscal incentives should be awarded to the very best performing buildings to enable the uptake of most novel technology and tools. Criteria for obtaining fiscal incentives must be updated over time. Non-fiscal incentives, such as expedited permits or increased floor area allowances, are also powerful in encouraging lower-energy new buildings. *Stakeholder feedback: There was no consensus that financial incentives will be widespread in 2030, though up to half might have them available for 2040. There was consensus that non-financial incentives are not widely used and that their growth will be modest. Examples of relevant forms include increased building area and expedited permitting.*

Box 5 • What is a building code?

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

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

Box 6 • Regional examples of policy action on new buildings

South Africa

The South African National Building Regulation has 23 chapters with SANS10400X and SANS10400XA dealing with environmental sustainability and energy usage respectively (SANS 10400 Building Regulations, n.d.). The requirement under energy usage consist of standards for building envelope and hot water supply. [SANS 204:2011](#) is a standard specifically for design requirements for energy efficiency in building. The requirements include site orientation, building orientation, building design, building sealing, services, and mechanical ventilation and air conditioning.

Rwanda

The Green Building Minimum Compliance system is an annex to the revised Rwanda Building Code passed in 2019, and is applicable to new commercial buildings, public buildings, assembly buildings, health facilities and educational buildings. It is a point-based system to help building owners and developers choose indicators based on the applicability to the building type, usage and the associated benefits. A total of 29 green building indicators are included in five modules – energy efficiency, water efficiency, environmental protection, indoor environmental quality and other green features. The green building indicators encourage the design of efficient building envelopes, maximising natural ventilation and daylighting, energy-efficient equipment and appliances, and renewable energy technologies to name a few (GGGI, 2019).

Ghana

The Ghana Building Code GS1207 of 2018 has a chapter dedicated to energy efficiency. It presents requirements applicable to private buildings throughout Ghana that are above 5 000 m² total gross floor area and public buildings located in all the regional capitals, Accra, Kumasi and Takoradi, that are above 500 m² in total gross floor area. The energy efficiency requirements include passive design strategies, namely natural ventilation, passive cooling and daylighting. It also sets requirements for materials used in the construction of schools, roads, hospitals and all public construction, with the aim to create a uniform cost for construction and guarantee structural integrity (Ghana Green Building Council, 2018).

Cabo Verde

The Building Energy Efficiency Code, enacted in 2017, is applicable to new commercial buildings and existing ones undergoing a deep retrofit, and includes educational and health facilities, hotels, offices and multipurpose buildings. The directive emphasises the use of bioclimatic strategies that take into account local climate and conditions, such as orientation, daylighting, shading, natural ventilation and ventilation openings.

Nigeria

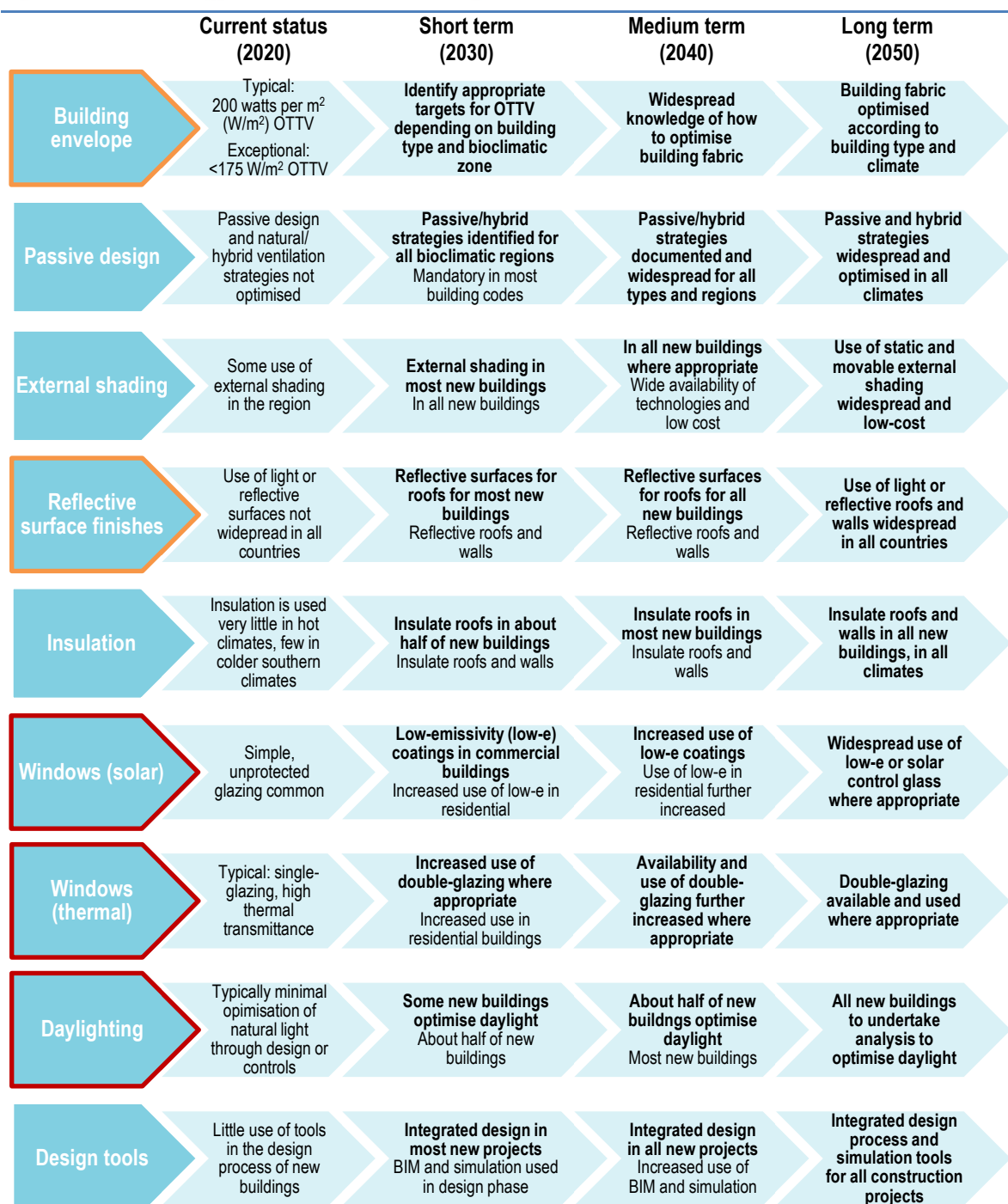
The Building Energy Efficiency Code (BEEC), launched in 2017, sets minimum standards for the energy efficiency of new residential and office buildings. Under the BEEC, two compliance methods are possible – prescriptive and performance. For the prescriptive option, projects must adhere to all the requirements as a checklist. The performance option involves energy calculations and energy simulation software. As an incentive for building owners and developers to comply with the BEEC, a comparative building label was developed, which rates a building depending on how many of the BEEC initiatives have been implemented (Africanism Online, n.d.).

Technology for sustainable new buildings

The technologies listed in Figure 14 have been identified as the key technologies or strategies needed to reach the long-term objective of decarbonising the buildings sector.

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

Figure 14 • Technology timelines for new buildings in Africa



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

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

- **[data gap] Building envelope:** The overall thermal transfer value (OTTV) is a measure of the building envelope performance including conduction and radiation heat transfer. This includes the performance of the building structure, insulation and windows. Lower OTTV can be achieved through optimised material choices and passive design strategies including building form, orientation, thermal mass, shading, the use of reflective surfaces to limit solar gain, and the use of vegetation, for example in cool roofs. *Stakeholder feedback: There was large divergence and uncertainty in common typical values; however, there was consensus on the rate of improvement of the typical value.*
- **Passive design:** Strategies for the most cost-effective combination of thermal performance of the building fabric, control of solar gains and ventilation, and daylight are highly dependent on the building type, how it will be used, and the macro- and micro-climate in which it is situated. Therefore, passive design strategies 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. *Stakeholder feedback: Vernacular architecture includes passive cooling in northern hot climates and there was consensus that there is a need to increase its adoption in new buildings.*
- **External shading:** External shading in the form of horizontal, vertical, fixed or movable elements can be the most cost-effective method of blocking out solar radiation. Good shading can have the same effect on reducing the heat gain through windows as solar-performance glazing. *Stakeholder feedback: External shading is not widespread today; however, the view was that it would be increasingly adopted to “most” by 2050.*
- **[data gap] Reflective surface finishes:** Light-coloured surfaces or surfaces with reflective pigments reflect incoming solar radiation, therefore reducing the temperature of the surface. Reflective surface finishes are most effective on the surfaces most exposed to direct sunlight (generally the roof).
- **Insulation:** Insulation is one of the components of OTTV that should have specific targets for hot locations and cold locations. A material’s insulation performance is determined by its thermal conductivity. “U-value” is also commonly used to express how much heat will transfer through a given thickness of a particular material, where the lower the U-value, the better the material is as an insulator. It is important to note that insulation can be effective in hot climates as well as in cold climates, and is most effective in the component of greatest surface area (i.e. the roof for low and flat buildings, walls for tall buildings). Note: the benefits of increased insulation must be assessed over a whole-life-cycle carbon assessment, given the high embodied carbon of traditional insulating materials. The extent of insulation required must be determined by cost-benefit analysis taking into consideration the local climate. *Stakeholder feedback: Although insulation is available, it is not commonly used, but there was a consensus view that about half will use it by 2040 and most will make use of it by 2050.*

- **[ambition gap] Windows (solar):** The dominant source of heat transfer through glazing is through solar radiation. This can be reduced with low-e and low-SHGC glazing. Building design and advanced technologies can enable low solar heat gain during hot weather, while allowing visible light transmittance for natural daylighting; however, the most cost-effective way of avoiding excess solar gain is reducing the size of windows and providing shading, which should always be prioritised. *Stakeholder feedback: There was a strong consensus that the use of low-e or solar-performance glass would be limited through to 2050.*
- **[ambition gap] Windows (thermal):** Heat transfer by conduction through windows can be reduced through a transition to double- or triple-pane windows, which have lower thermal transmittance, or U-value. When produced at scale, these types of windows can be highly cost-effective. These windows also provide noise protection, improve thermal comfort, and can enable passive architecture and natural ventilation. *Stakeholder feedback: There was a consensus that the use of double-glazing is limited but that about half of new buildings should make use of it by 2030, growing more widespread by 2040. The use of triple glazing is considered to remain limited.*
- **[ambition gap] Daylighting:** Access to views and to daylight are essential for building occupant well-being, health and productivity. Building design should ensure that all spaces have access to natural light and views, and have glare-free, adequate daylight levels for large portions of the day through improved control. However, there is a need to optimise the ingress of natural light with the control of excessive solar radiation. *Stakeholder feedback: There was little use of daylighting in existing buildings and there was no consensus for when natural lighting would become widespread.*
- **Design tools:** The integrated design process of involving all disciplines of a building project from the early stages of the project enables the adoption of many more passive design measures than when disciplines are brought on at later stages. Other tools with significant potential to optimise passive measures and design choices include thermal and energy dynamic simulation, daylight simulation, and BIM. *Stakeholder feedback: There was strong consensus that these tools will become mainstream by as early as 2030.*

Box 7 • Regional examples of action on new buildings technology

Morocco

The thermal regulation code ([decree No. 2-13-874](#)), which was adopted in October 2014, introduced minimum technical requirements in terms of thermal performance for new constructions for residential and tertiary use (social housing and freestanding buildings in the residential sector and hotels, offices, educational facilities and hospitals in the commercial sector). Each of Morocco's six climate zones has its own specific thermal requirements. Their implementation became mandatory in November 2015. The labelling of buildings in terms of thermal performance is voluntary, seeing this as adding value. The thermal regulation is based on a two-tier approach: 1) a "performance-based" approach to the maximum energy consumption for the building's heating and air conditioning, expressed in kilowatt-hours per square metre per year; and 2) a "prescriptive" approach which sets targets for the thermal properties of the various components of the envelope (roofs, exterior walls, windows, floors), according to the climate zone and window ratio.

Kenya

International Green Structures (IGS) is an organisation focused on providing solutions to the global housing crisis. In Africa, the company is located in Nairobi and provides its services to other East African countries. IGS manufactures compressed agricultural fibre panels, which not only reduces the construction time and increases the quality of construction but also provides an opportunity for farmers to earn a second income (Barnes, 2015).

Finance for sustainable new buildings

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

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

Capacity building for sustainable new buildings

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

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

Table 6 • Capacity building for new buildings in Africa

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

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

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

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





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

Multiple benefits of sustainable new buildings

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

Some of these benefits are described in Table 7, although many of them require further analysis to quantify them: Page | 57

Table 7 • Multiple benefits of new buildings

Environment	
	<ul style="list-style-type: none"> • Emissions reductions – sustainable new buildings deliver GHG reductions because they consume less, and cleaner, energy. • Air quality – sustainable new buildings and zero-emission buildings reduce air pollution. • Resource efficiency – sustainable buildings reduce the use of materials used in construction and increase the useful life of buildings and their components.
Energy	
	<ul style="list-style-type: none"> • Energy savings – sustainable new buildings are more energy-efficient. • Energy security – sustainable new buildings use less energy and put less strain on energy systems. • Energy prices – sustainable new buildings reduce energy consumption and peak loads, lowering network infrastructure and system costs.
Economy	
	<ul style="list-style-type: none"> • Economic performance – sustainable new buildings create employment for sustainability services and reduce building operation costs, freeing up resources to invest in other parts of the economy. • Productivity – sustainable new buildings can increase the productivity of students and employees through improved thermal comfort, lighting and noise. • Asset value – sustainable new buildings have strong asset values and flow-on effects for nearby properties and investment attraction.
Society	
	<ul style="list-style-type: none"> • Poverty alleviation – sustainable new buildings reduce building operation costs. • Health and well-being – sustainable new buildings deliver increased thermal comfort, light, noise and indoor air quality, improving physical and mental health and well-being.



Activity 3: Existing buildings

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

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

Box 8 • Existing buildings in Africa: Trends and challenges

African construction activities in [real estate are a significant source of economic activity](#), with estimates of the share of this sector making up 22% of large projects in 2019 and having stayed consistent in this share for the last four years. However, there are regional trends in this investment across the continent. North, east, and central Africa have all seen a considerable growth in large real estate construction projects (from less than 4% in 2015 to over 20% in 2019), while west Africa and southern Africa have seen a recent slowdown in construction activities. This change in investment patterns reflects the shifting migration and urbanisation patterns and the related economic growth these bring across the continent.

While the construction growth rate is much higher compared with the rate of renovation of existing buildings in Africa (only 30% of the building stock anticipated for 2040 currently exists), there is still great scope in energy efficiency improvements of existing building stock.

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

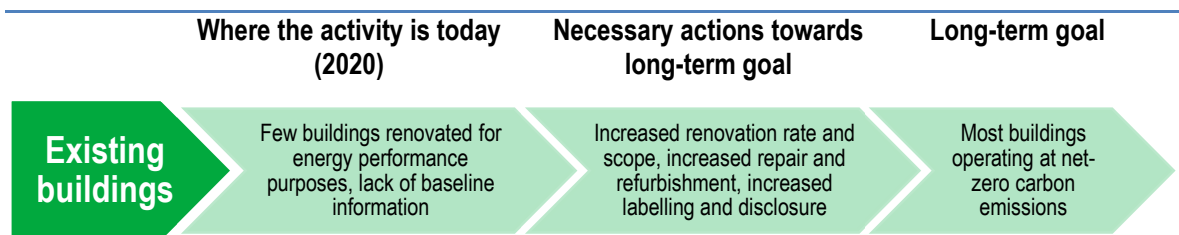
A key shift in terms of buildings and energy is the change in access to electricity over the past decade, with considerable improvements in access rates across a majority of the African continent. Since 2009, the proportion of population with access to electricity in sub-Saharan African has grown from around 30% to more than 40% in 2019. Higher rates exist among urban populations, with rates over the last decade moving from 68% to 78%, but remain low among several central African countries and rural households.

There is generally a lack of priority to carry out building renovations. This is partly due to the lack of financial support and the high perceived costs, but also lack of awareness of the economic benefits brought by energy retrofits.

None of the few existing building codes in Africa covers the retrofit of existing buildings.

Key actions for sustainable existing buildings

Figure 15 • Key actions for existing buildings in Africa



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

- **Increase renovation rates.** Annual renovation rates in the region should reach 1.5% by 2025 and 2% by 2040. Much of this renovation will occur among buildings 25 to 30 years old whose systems are reaching the serviceable end of life.
- **Increase the depth of renovation.** Enable deep energy renovations that reduce energy consumption of existing buildings by 30-50% or more. Design and implement a standard for an appropriate level of consequential improvements for key appliances and systems (e.g. windows and heating/cooling systems) when undertaking major refurbishment.
- **Enable renovation investments.** Enable increasing renovation rates by increasing access to and use of finance to enable private investment in renovations.
- **Governments lead by example.** Develop policies that ensure existing government buildings are renovated to be low-emission and efficient. Across sub-Saharan Africa, governments are major owners and operators of existing buildings and this stock can be used to set higher performance standards and familiarise the market and financial institutions.

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Stakeholders for sustainable existing buildings

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

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

Table 8 • Stakeholder mapping for existing buildings in Africa

National government	Subnational government	Utility companies	Property and project developers	Financial institutions	Architects and engineers	Manufacturers, retailers and suppliers	Labourers and installers	Building owners and occupants	Civil society **

* of appliances and materials

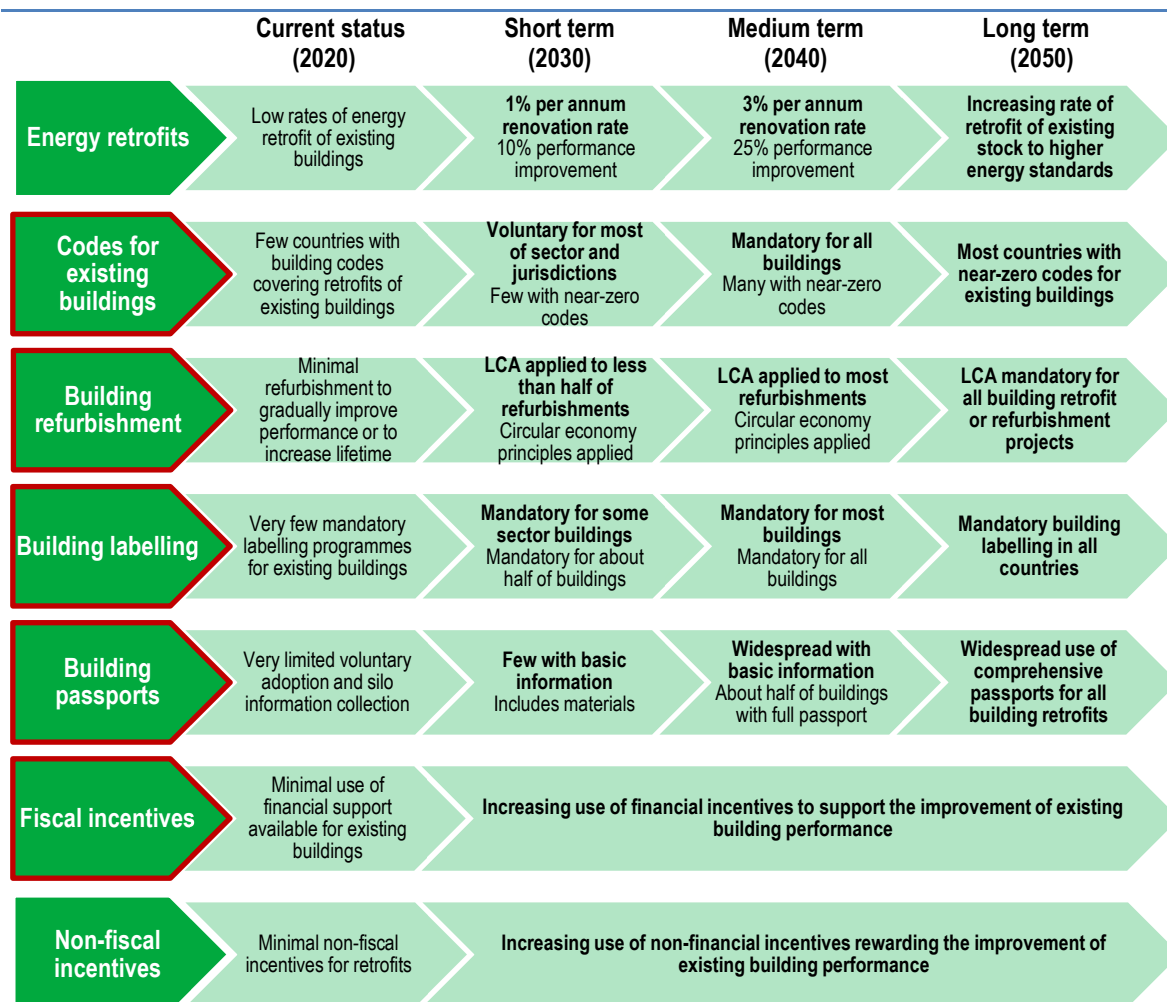
** including academia, NGOs, research institutions, social networks and community associations.

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

Policy for sustainable existing buildings

The key policies for driving the performance of existing buildings are outlined in Figure 16:

Figure 16 • Policy timelines for existing buildings in Africa



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

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

- **Energy retrofits:** An energy retrofit can be defined as an undertaking of structural, architectural, mechanical or electrical works with the aim of improving the energy performance of an existing building. While these types of works are rarely carried out for their energy benefits alone, they should become increasingly widespread, and be more ambitious in their performance improvement targets. Buildings should be retrofitted to their cost-effective potential as rapidly as they can, even if the works happen over the course

of several years. *Stakeholder feedback: There was a strong consensus that cost was a significant barrier to undertaking retrofits among the existing building stock.*

- **[ambition gap] Codes for existing buildings:** These refer to standards requiring improvements to the building's envelope or systems in the event of significant works, whether they were part of an energy retrofit or not. Codes should be developed with respect to particular segments (e.g. commercial, multifamily residential, single homes) and ensure that refurbishments are carried out to align the performance of existing buildings with their cost-effective potential. *Stakeholder feedback: There was a view that the proportion of retrofits covered by a building code is low and could increase to cover "about half" by 2050.*
- **[ambition gap] Building refurbishment:** Refurbishment works include ongoing works a building owner or manager may carry out on an existing building, without being so substantial they 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 in order to facilitate planning of works (i.e. to assess whether works should be done gradually 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. *Stakeholder feedback: Consensus was that LCA in refurbishment is not common practice, nor is it expected it will become widespread for existing buildings.*
- **[ambition gap] Building labelling:** Quantitative building energy labelling can be used to assess building envelope and system characteristics on a scale of less to more efficient. Labelling enables increased information sharing and awareness for consumers and investors, and should become widespread in existing buildings as well as new buildings, and should increasingly disclose the embodied and operational carbon of buildings with reference to a benchmark (see "Activity 4: Building operations"). *Stakeholder feedback: There was a view that labelling is not widespread for existing buildings, but may grow over time and apply to "about half" by 2050.*
- **[ambition gap] Building passports:** Building passports can be used to track information about the building, its materials, systems, energy use, renovations, sources of potential savings and other real estate information to improve decision-making processes. Basic information includes floor plans, floor area schedules, activity information, past retrofit of refurbishment works, and monthly energy consumption and peak demand. *Stakeholder feedback: There was no agreement that the adoption of building passports in existing buildings would be widespread by 2050.*
- **[ambition gap] Incentives:** Financial and non-financial incentives such as increased scope or special permits can be significant enablers of the refurbishment and retrofit of existing buildings. *Stakeholder feedback: Very few countries expect incentives to become more available for retrofits of existing buildings.*

Box 9 • Regional examples of policy action on existing buildings

Morocco

In 2014, the Ministry of Energy (MEMDD) and the Ministry of Religious Affairs initiated the project Green Mosques in co-operation with the Société d'Investissements Energétiques and the Agence Marocaine pour l'Efficacité Energétique (AMEE) with the objective of improving the energy performance of 15 000 existing mosques – new mosques have to comply with Morocco's recent thermal performance regulation. Over the period 2015-21, the MEMDD is implementing the programme with support from the German Federal Ministry for Economic Cooperation and Development (BMZ) and German Development Cooperation (GIZ), focusing on mosques and public buildings, as part of the BMZ Special Initiative for Stability and Development in the Middle East and North Africa region. The energy systems of 100 mosques have been modernised and works are under preparation in 600 more mosques. In the town of Tadmamt, the project supported the construction of an energy-plus mosque, and surveys of the existing energy situation of almost 1 000 mosques have been carried out by employees of the Ministry of Religious Affairs. The programme has achieved improvements thanks to efficient lighting, insulation, and solar water heating and solar PV technologies. A labelling system has been developed by AMEE and will be deployed in all the mosques, which are involved in the programme (GIZ, n.d.a).

South Africa

Energy Efficiency in Public Buildings and Infrastructure Programme (EEPPIP) promotes energy efficiency transformation of the public sector to reduce the GHG emissions in South Africa by providing financial and technical support to public building retrofitting and public infrastructure such as street lights and wastewater treatment plants. Other strategies implemented include capacity building and raising awareness, enabling private-sector investment, and enhancing the energy service companies (ESCOs) market (GIZ, n.d.b).

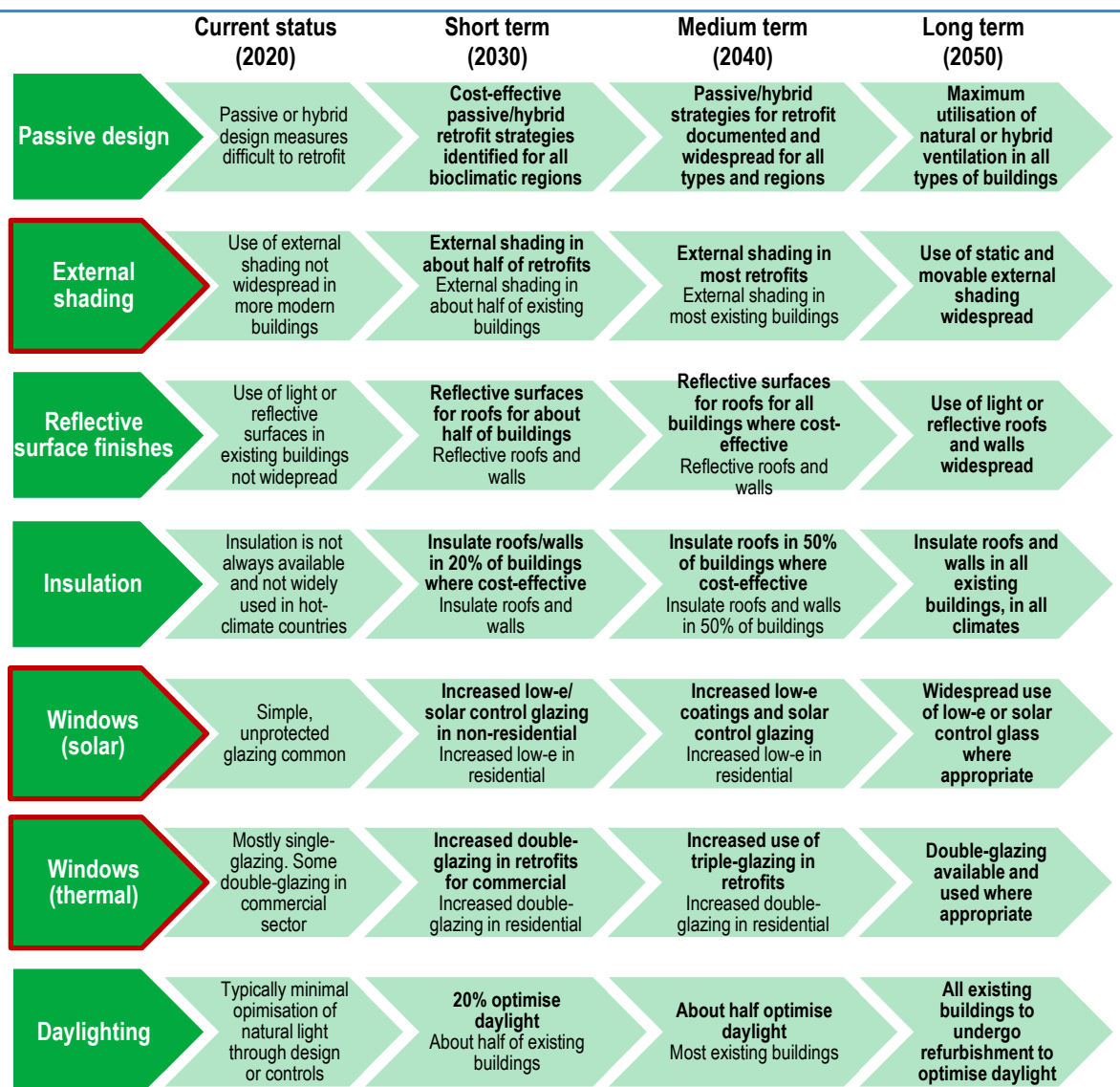
A range of models for implementing EEPPIP in the ESCO market are emerging that help to reduce the risk and liability across the stakeholder chain. The Carbon Trust is promoting a model in [South Africa that would see a Guarantee Fund](#) established within an Industrial Development Corporation, which would help to unlock access to credit lines for ESCOs to contract with public-sector institutions, by providing a partial credit guarantee against defaults or payment delays. This type of financing would be applied where there is a fairly low risk of total default that results in contract termination, but where there are expected to be a high number of liquidity issues.

Technology for sustainable existing buildings

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

Specific targets and timelines for sustainable existing building technologies are outlined in Figure 17:

Figure 17 • Technology timelines for existing buildings in Africa



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

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

information or insufficient agreement among responses, the item is highlighted with an **orange mark**, denoting it as an area that requires additional information and consultation.

- **Passive design:** Strategies for the most cost-effective implementation of passive design measures such as upgrade of the building fabric, control of solar gains and ventilation, and daylight are highly dependent on the building type, how it will be used, and the macro- and micro-climate in which it is situated. Therefore, passive design strategies must be developed for specific bioclimatic regions and specific building types, and special considerations must be taken when applied to existing buildings. These locally adapted design guidelines specific to the retrofit of existing buildings can ensure that passive strategies can be optimised before relying on active systems. In combination with fans or active systems, hybrid solutions can provide significant energy savings when compared with a 100% active solution.
- **[ambition gap] External shading:** External shading in the form of horizontal, vertical, fixed or movable elements can be the most cost-effective method of blocking out solar radiation. Good shading can have the same effect on reducing the heat gain through windows as solar-performance glass. *Stakeholder feedback: Slow progress in the inclusion of external shading to retrofits was expected between now and 2050.*
- **Reflective surface finishes:** Light-coloured surfaces or surfaces with reflective pigments reflect incoming solar radiation. Reflective surfaces are most effective on the largest surfaces exposed to the sun, which normally will be the roof. Painting external building surfaces can also be an effective and relatively low-intrusion retrofit measure.
- **Insulation:** Insulation is one of the components of OTTV that should have specific targets for hot locations and cold locations. A material's insulation performance is determined by its thermal conductivity. "U-value" is also commonly used to express how much heat will transfer through a given thickness of a particular material, where the lower the U-value, the better the material is as an insulator. It is important to note that insulation is important in hot climates as well as in cold climates, and is most effective in the component of greatest surface area (i.e. the roof for low and flat buildings, walls for tall buildings). Note: the benefits of increased insulation must be assessed over a whole-lifecycle carbon assessment, given the high embodied carbon of most insulating materials. *Stakeholder feedback: There was consensus that insulation in retrofits is used little today and a view that it will increase to become applied to "most" by 2050.*
- **[ambition gap] Windows (solar):** The dominant source of heat transfer through windows is through solar radiation. This can be reduced with low-e and low-SHGC windows. Building design and advanced technologies can enable low solar heat gain during hot weather, while allowing visible light transmittance for natural daylighting; however, the most cost-effective way of avoiding excess solar gain is reducing the size of windows and providing shading. *Stakeholder feedback: There was consensus that low-e glazing is not regularly used. It may become widespread by 2050 only in retrofits.*
- **[ambition gap] Windows (thermal):** Heat transfer by conduction through windows can be reduced through a transition to double- or triple-pane windows, which have lower thermal transmittance, or U-value. When produced at scale, these types of windows can be highly cost-effective. These windows also provide noise protection and improve thermal comfort, and can enable passive architecture and natural ventilation. Note: the benefits of double- or triple-pane glazing must be assessed over a whole-lifecycle carbon assessment, given the high embodied carbon of traditional glass manufacturing. *Stakeholder feedback: There was a view that double-glazing will become mainstream between 2030 and 2040, with triple-glazing becoming used from 2050 in some cases.*

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

Box 10 • Regional examples of actions on existing buildings technology

Regional

The [Million Cool Roofs Challenge](#) is a project of the Kigali Cooling Efficiency Program (K-CEP). The challenge was granted to ten teams to deploy solar reflective coating and/or materials to address thermal stress. The African finalists of the 2019-20 edition included South Africa, Niger, Kenya, Cote d'Ivoire, Senegal and Rwanda. In Niger, for example, the proposal was designed to stimulate the private sector and create a market for solutions and products for cold coverings, while raising awareness about the solutions for cold coverings. In turn, in Cote d'Ivoire, the project linked the deployment of a cold roof demonstration to funds generated by the mobilisation of schools and neighbouring communities in the collection and sale of waste to recyclers.

Finance for sustainable existing buildings

Finance tools particularly relevant to existing buildings may include:

- **Dedicated credit lines:** Funding delivered through banks for a specific purpose, which can prioritise sustainable buildings, construction or development projects. Dedicated credit lines to national or local governments can also be used to establish a revolving loan fund, which collects repaid loans for energy efficiency projects and reinvests them in additional energy efficiency projects.
- **Risk-sharing loan/loan guarantee/concessional loan:** Large organisations, such as a government, international bank or aid organisation, covering the risk of payment default to allow banks to fund projects with lower costs and better loan terms.
- **Green bonds:** Bonds that can be used to bundle funding for projects with climate or environmental benefits.
- **Preferential tax:** Direct funding from the government to reduce or eliminate taxes for sustainable products and services.
- **Grants and rebates:** Direct funding to overcome upfront cost barriers, provided by a government, organisation or programme either through a competitive process (grants) or during or after the purchase of a sustainable product or service (rebates).
- **Energy performance/energy service contracts:** Contracts for services or delivered savings typically are delivered by an ESCO, which can include a range of energy efficiency services and products.
- **Green mortgages:** Prospective homeowners can solicit additional finance as part of their mortgage to install efficient features and technologies in their future homes.
- **Procurement purchase and lease:** The purchase or lease of sustainable products and services. Leasing enables the ability to use energy-efficient products on a rental basis to reduce a capital expenditure.
- **On-bill/tax repayment:** An approach where any recurring bill, such as utility bills, insurance bills or home improvement store bills, can collect small amounts of money over a long period of time to pay for energy efficiency purchases in smaller payments. An offshoot of on-bill finance, tax repayment is a mechanism of recurring tax payments that the tax authority uses 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 paid in full.

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

Capacity building for sustainable existing buildings

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

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

Table 9 • Capacity building for existing buildings in Africa

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

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

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

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

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

Multiple benefits for sustainable existing buildings

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

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

Table 10 • Multiple benefits of existing buildings

Environment



- **Emissions reductions** – sustainable retrofits to existing buildings can deliver GHG reductions through lowered energy consumption.
- **Air quality** – sustainable retrofits to existing buildings can reduce air pollution.

Energy



- **Energy savings** – sustainable retrofits to existing buildings deliver energy efficiency improvements.
- **Energy security** – sustainable retrofits improve the energy efficiency of existing buildings and put less strain on energy systems.
- **Energy prices** – sustainable retrofits to existing buildings reduce energy demand and peak loads, lowering network infrastructure and system costs.

Economy



- **Economic performance** – sustainable retrofits to existing buildings create employment for sustainability services and reduce building operation costs, freeing up resources to invest in other parts of the economy.
- **Productivity** – sustainable retrofits to existing buildings increase the productivity of students and employees through improved thermal comfort, lighting and noise.
- **Employment** – sustainable retrofits to existing buildings boost employment through new design and construction services for increased sustainability, including quality assurance and commissioning.
- **Asset value** – sustainable retrofits to existing buildings make buildings more durable with lower O&M costs.

Society



- **Poverty alleviation** – sustainable retrofits to existing buildings reduce building operation costs.
 - **Health and well-being** – sustainable retrofits to existing buildings can deliver increased thermal comfort, light, noise and indoor air quality, improving physical and mental health and well-being.
 - **Safety and security** – retrofits to existing buildings can include features such as building automation, sensors and lighting that can deter crime, improving safety and security.
-



Activity 4: Building operations

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

Box 11 • Building operations in Africa: Trends and challenges

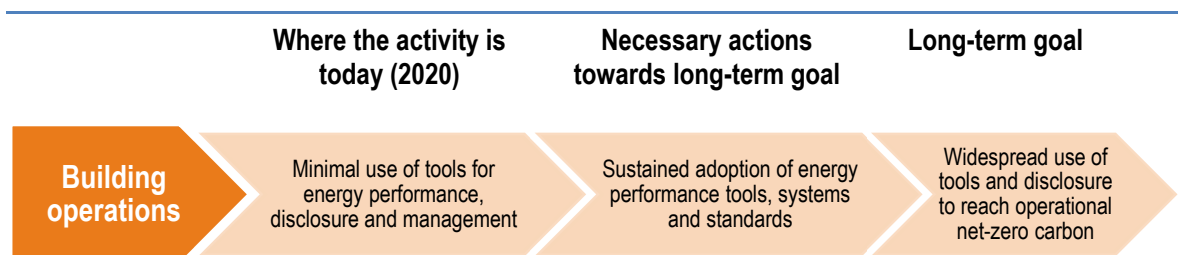
While there are efforts being taken towards the construction of energy-efficient buildings in Africa, the region has no or very few mandatory policies in place related to building operations. Technologies such as BMS or smart sensors and controls are not widely utilised mainly due to the investment costs (perceived or real) as well as to lack of information regarding the technologies.

Energy management systems (EMS) and auditing procedures that identify opportunities for increased efficiency are still not mainstream, even in commercial or large energy-using buildings.

Technologies such as BMS or smart sensors and controls are also underutilised mainly due to the high cost, lack of information regarding the available technologies, and low priority placed by businesses and governments.

Key actions for sustainable building operations

Figure 18 • Key actions for building operations in Africa



Key actions to improve the operations of buildings include:

- **Rating tools and disclosure.** Develop national or subnational tools that enable the benchmarking and evaluation of a building's energy performance and develop disclosure schemes to enable comparison and incentivise improved performance. In sub-Saharan Africa, several certification tools are being used for rating low-emissions buildings, such as the Green Star SA tool and the Net Zero/Net Positive Certification in South Africa. However, focusing on establishing benchmarks and disclosing building performance, particularly in the public sector, will help familiarise and create a market for the service.
- **Energy audits.** Promote the use of regular energy audits to identify inefficiencies in building operations and systems. Across Africa, audits are not yet widely performed and will provide a meaningful process for regular checking of system performance, particularly among large energy-using sectors.
- **EMS.** Provide tools and training for EMS and use energy management processes in all buildings, particularly non-residential buildings. Across the region, the use of BMS is more common among large or prestige building types, but adopting these more widely will help to better manage demand and current supply constraints.
- **Smart controls.** The use of digital sensors and controls can enable better managing of building operations, such as temperature, lighting and ventilation systems controls. Installing energy metering and linking with BMS and EMS can also enable better management when correctly adopted. Across Africa, smart controls were not seen as having much potential. Therefore, putting in place regulations on communication standards can help ensure these systems are well integrated across platforms.
- **Building passports.** Developing and supporting a system for regular information collection related to building system operations and energy use will support the availability of and access to building information to current and subsequent owners and those who work with the building.

Stakeholders for sustainable building operations

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

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

Table 11 • Stakeholder mapping for building operations in Africa

National government	Subnational government	Utility companies	Property and project developers	Financial institutions	Architects and engineers	Manufacturers, retailers and suppliers*	Labourers and installers	Building owners and occupants	Civil society **

* of appliances and materials

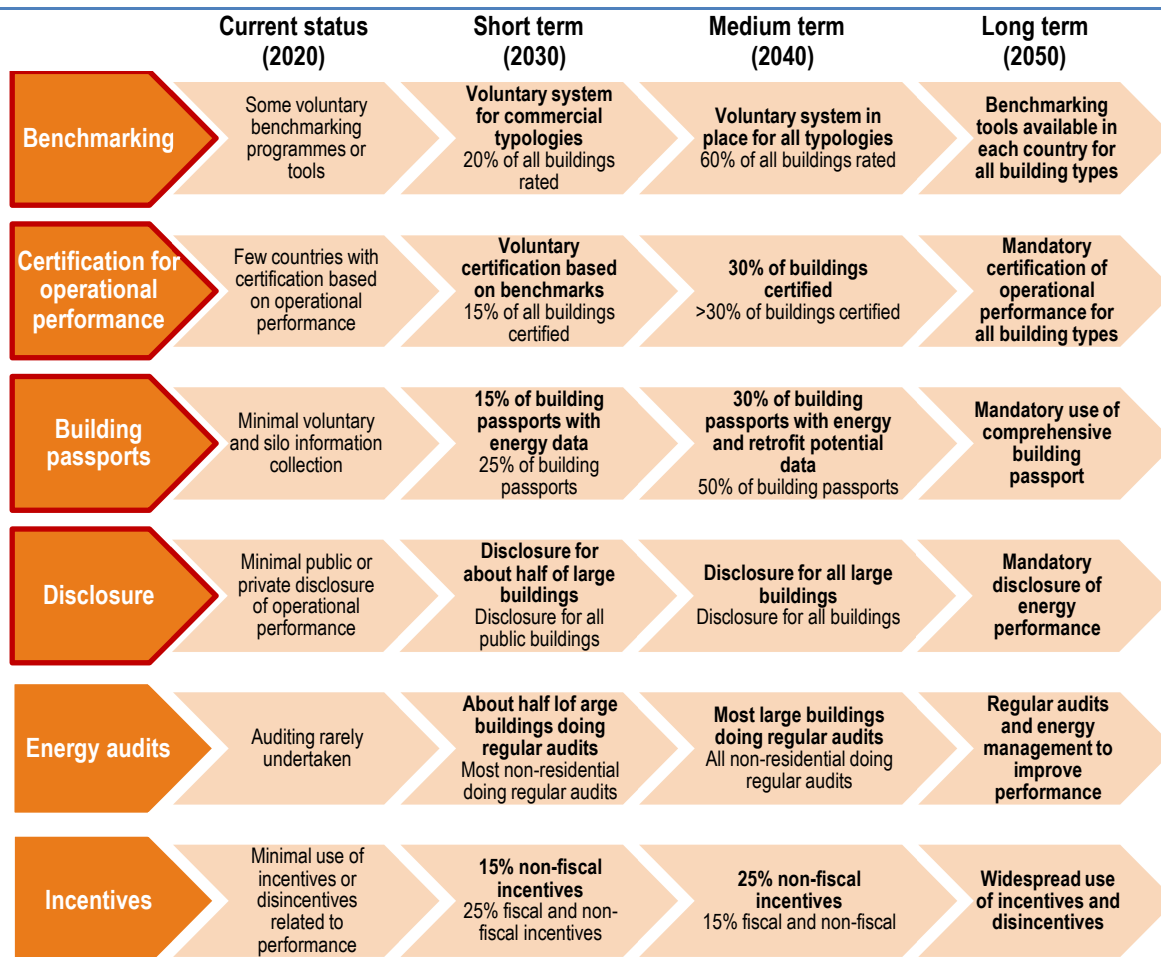
** including academia, NGOs, research institutions, social networks and community associations.

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

Policy for sustainable building operations

Policies can be developed to promote highly efficient building operations. Within the targets for sustainable building operations, the policy sub-targets and timelines in Figure 19 offer more details:

Figure 19 • Policy timelines for building operations in Africa



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

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

- **[ambition gap] Benchmarking:** By tracking performance and comparing that performance with other buildings, sustainability managers can make educated investment decisions to improve the overall performance of the building operations. Benchmarking can also support energy disclosure, certification and building passport goals. Robust data collection is necessary to create locally appropriate benchmarks for comparison. *Stakeholder feedback: Few tools exist to assess operational energy performance, and consensus was that adoption will slow to about half of buildings by 2050.*

- **[ambition gap] Certification for operational performance:** Building energy or sustainability certification and labelling can be used to disclose performance of the existing building and enforce performance requirements. The certification may be linked to benchmarking tools. The certificate or label can enable increased information sharing and documentation for consumers and financial decisions. The certification of operational performance can also allow the development of green lease agreements, where there is a binding agreement between the property owner and the tenant to enable the property owner to operate the building in accordance with its potential. *Stakeholder feedback: There was a view that certification of existing buildings is not widespread and would be very slow in its adoption by 2050.*
- **[ambition gap] Building passports:** Building passports can be used to track information about the building, materials, systems, energy use, renovations and other real estate information to improve decision-making processes with improved data that are tracked and stored. *Stakeholder feedback: There was a consensus that building passports will be very slow in their uptake between now and 2050.*
- **[ambition gap] Disclosure:** Mandatory disclosure of energy performance, certificates or benchmark rating of buildings can support improved data collection, decision-making and competition. *Stakeholder feedback: There was a strong view that disclosure of performance will become widespread by 2050, but that this would not apply to large users.*
- **Audits:** Regular energy audits are powerful tools to assess opportunities for energy-saving measures, and should be performed regularly, particularly in buildings with high energy consumption. *Stakeholder feedback: There was a strong view that audits should be performed regularly, particularly in large energy users and eventually all non-residential buildings by 2050.*
- **Incentives:** Non-financial incentives, such as expedited permits or increased floor area allowances, can encourage sustainable buildings operation. Financial incentives should be used to support the very best performing buildings. Both should be linked to building certification or disclosure policies. *Stakeholder feedback: There was consensus that incentives are limited and uncertainty if they will become increasingly available over time.*

Box 12 • Regional examples of policy action on building operations

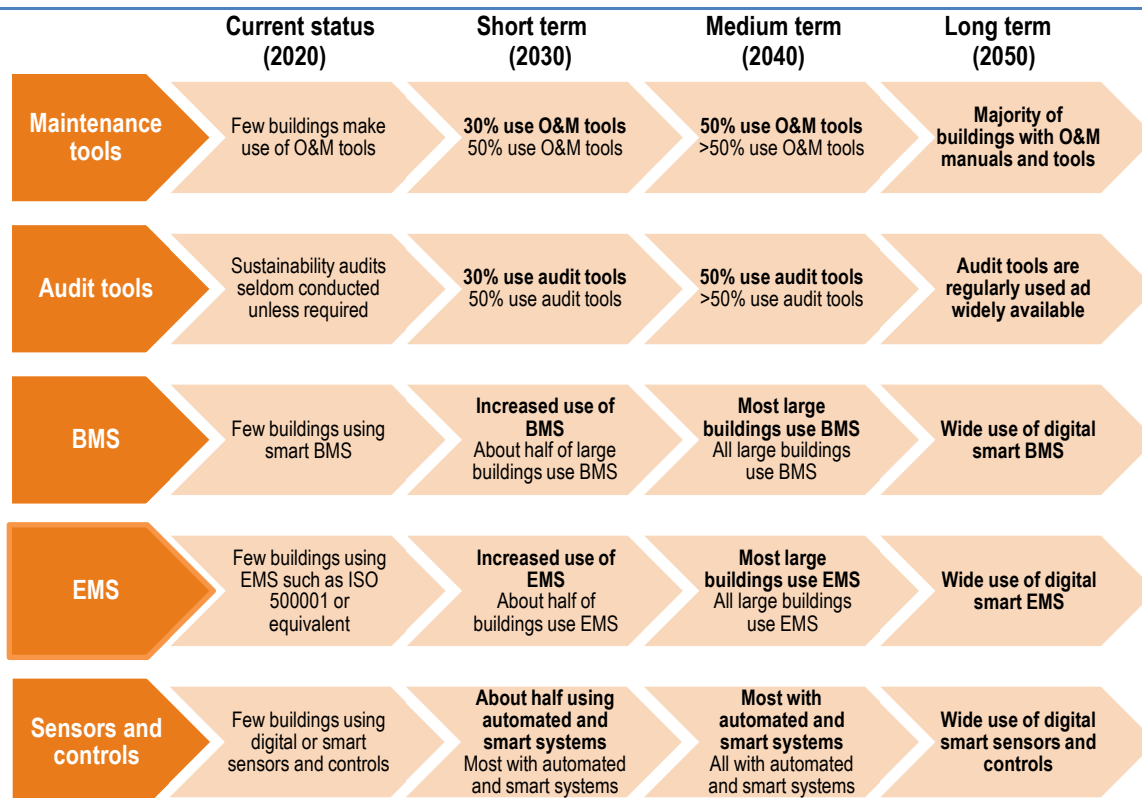
Kenya

The Community Education and Empowerment Centre (CEEC), with the support of the Ministry of Energy and the Danish International Development Agency, provides subsidies for energy auditing services to companies interested in reducing energy usage. CEEC also provides training sessions providing strategies for energy management (C40 Cities, USGBC and WorldGBC, 2015).

Technology for sustainable building operations

Specific targets and timelines for the sustainable building operation technologies are outlined in Figure 20:

Figure 20 • Technology timelines for buildings operations in Africa



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

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

- **Maintenance tools:** O&M manuals 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 BMS. *Stakeholder feedback: There was consensus that O&M tools will become widespread by 2050.*
- **Audit tools:** Building energy and/or sustainability audits provide an opportunity to systematically check the optimisation of system configurations and to identify priority retrofit measures. Audit tools (e.g. software, sensors and thermal cameras) can reduce the

cost to conduct an audit and improve the rate of annual building audits. *Stakeholder feedback: There was consensus that audit tools will become widespread by 2050.*

- **BMS:** BMS can range from full-scale building software to simple controls that manage individual technologies within a building. Increasingly, digital tools are connecting multiple systems within a building with learning and fault detection to improve the overall management of the building system controls. *Stakeholder feedback: There was consensus that BMS would become widespread by 2050.*
- **[data gap] EMS:** EMS enable monitoring of energy consumption of systems, components and/or the building as a whole to identify anomalies and understand energy consumption trends. A network of digital energy meters or sensors or a simple smart meter can form the basis of an EMS. Smart meters can support a better customer experience through in-home displays informing time-of-use pricing. Combined with prepayment, they can help to control costs and manage the energy use through updated user readings.
- **Sensors and controls:** Sensors and controls are fundamental to smart maintenance, audit, energy management and building management. Control systems can range from fully centralised systems to simpler systems such as programmable thermostats. Sensors and controls are increasingly starting to incorporate machine learning to understand occupant preferences and behaviour, and optimise system settings based on internal and external conditions. *Stakeholder feedback: There was consensus that smart sensors and controls could become widespread in most buildings by 2050.*

Box 13 • Regional examples of action on building operations technology

Nigeria

The [Energy Commission of Nigeria](#) initiated the first detailed energy audit of three public buildings in 2016 to develop a plan for reducing energy consumption by identifying energy-saving measures. The report of the audit was published detailing the outcomes of the assessment and the recommendations, and serves as a guide to promote the adoption of energy efficiency measures in Nigeria and to strengthen energy efficiency policies (Energy Commission of Nigeria, Japan International Cooperation Agency, 2017).

Tanzania and Ghana

[Devergy](#) provides a solar direct current (DC) micro-grid that aims to serve basic needs, such as lighting and phone charging. When connecting a new village, Devergy installs solar panels, solar batteries and a meter in the home or small business (usually one solar tripod for five to ten houses). In-house software allows remote monitoring and control of electricity in each home, and the customers top up using prepaid cards.

Finance for sustainable building operations

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

Finance tools relevant to building operations may include:

- **Dedicated credit lines:** Funding delivered through banks for a specific purpose, which can prioritise sustainable buildings, construction or development projects. Dedicated credit lines to national or local governments can also be used to establish a revolving loan fund, which collects repaid loans for energy efficiency projects and reinvests them in additional energy efficiency projects.
- **Risk-sharing loan/loan guarantee/concessional loan:** Large organisations, such as a government, international bank or aid organisation, covering the risk of payment default to allow banks to fund a project with lower costs and better loan terms.

- **Preferential tax:** Direct funding from the government to reduce or eliminate taxes for sustainable products and services.
- **Grants and rebates:** Direct funding to overcome upfront cost barriers, provided by a government, organisation or programme either through a competitive process (grants) or during or after the purchase of a sustainable product or service (rebates).
- **Energy performance/energy service contracts:** Contracts for services or delivered savings, typically delivered by an ESCO, which can include a range of energy efficiency services and products.
- **Procurement purchase and lease:** The purchase or lease of sustainable products and services. Leasing enables the ability to use energy-efficient products on a rental basis to reduce a capital expenditure.

Capacity building for sustainable building operations

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

The types of capacity-building activities relevant to building operations are mapped in Table 12, where the darker the colour, the higher the impact that capacity building type has for this activity.

Table 12 • Capacity building for building operations in Africa

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

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

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

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

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

Multiple benefits of sustainable building operations

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

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

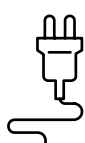
Table 13 • Multiple benefits of sustainable building operations

Environment



- **Emissions reductions** – more sustainable building operations deliver GHG reductions through lowered energy consumption.
 - **Air quality** – sustainable building operations reduce air pollution.
-

Energy



- **Energy savings** – sustainable building operations result in the more efficient use of building systems.
 - **Energy security** – sustainable building operations deliver reductions in energy use and put less strain on energy systems.
 - **Energy prices** – sustainable building operations reduce energy demand and peak loads, lowering network infrastructure and system costs.
-

Economy



- **Economic performance** – sustainable building operations reduce operating costs, freeing up resources to invest in other parts of the economy.
 - **Productivity** – sustainable building operations can enable increased thermal, light and acoustic comfort, which can result in improved productivity of occupants.
 - **Employment** – sustainable building operations can grow employment through operational services for increased sustainability.
-

Society



- **Poverty alleviation** – sustainable building operations result in lower costs.
 - **Health and well-being** – sustainable building operations can deliver increased physical and mental health through retro-commissioning and building management that increases thermal, light and acoustic comfort.
 - **Safety and security** – sustainable building operations can contribute to improved building management, O&M, avoiding, for example, system failure.
-



Activity 5: Appliances and systems

Energy-consuming lighting, appliances and equipment systems commonly have a shorter lifetime than the buildings themselves and offer significant opportunity to reduce emissions in new and existing buildings. Aside from increasing appliances' efficiency, the human behavioural factors must also be considered: the manner in which users operate appliances (e.g. operating air conditioners at temperature set points that are lower than required). Some trends and challenges for appliances and systems in Africa are explored in Box 14.

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

Increasing incomes and living standards, as well as improved access to affordable and reliable electricity, leads to a steady increase in energy consumption in the residential sector. Without strong action to ensure energy efficiency, the region could face a "lock-in" of inefficient appliances and equipment.

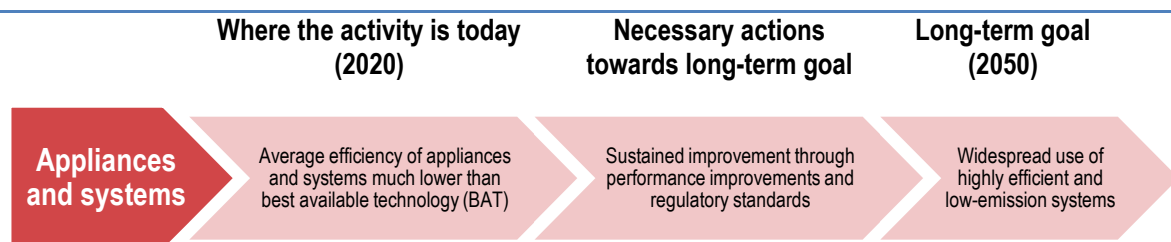
Approximately 680 million people in Africa (more than half of the population) currently live in areas that may need cooling systems. This share varies by country: in Egypt and Tanzania, less than 40% of the population live in places that have daily average temperatures above 25°C, while in countries such as Niger, Senegal and Sudan, nearly the entire population does.

Yet ownership of cooling devices is rare; air-conditioner ownership across Africa averages only 0.06 units per household, while fans are much more common, averaging 0.6 units per household. Ownership rates reflect differences in income levels and climate. Wealthier countries such as Morocco, Algeria and Tunisia have air-conditioner ownership rates that are three times the African average, despite a lower-than-average number of cooling degree-days. In contrast, less affluent countries with much higher cooling needs, such as Togo, Senegal and Niger, have ownership levels that are half the African average or less.

In other parts of the world, mandatory MEPS or labelling systems have enabled consumers to make energy-efficient choices. This could be coupled with more efficient heating, ventilation and air conditioning (HVAC) systems to reduce energy consumption in buildings. In the case of HVAC systems, the concept of energy recovery could also be promoted. The use of smart controls and smart management systems is another field that could be developed.

Key actions for sustainable systems

Figure 21 • Key actions for appliances and systems in Africa



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

- **MEPS.** Develop, enforce and improve standards that set product quality and performance requirements. Across Africa, MEPS are present but could be further strengthened and cover a greater number of appliances and systems. For example, South Africa and Ghana have set mandatory standards for lighting, cooling and heating systems and a number of white-good products. Moving from voluntary to mandatory standards will also ensure system energy performance is further improved such as through the Energy Efficiency for Lighting and Appliances initiative from eastern and southern Africa (East African Community and Southern African Development Community). Regional co-operation by harmonising standards and testing protocols may facilitate deployment particularly in smaller markets.
- **Enable investment in clean and efficient systems.** Enable increasing use of sustainable products by increasing access to and use of finance to enable private investment. The rate of investment in energy efficiency across sub-Saharan Africa needs to at least double its current level and focus on improving access to financial tools to support low-emission technology investment.
- **Governments lead by example.** Develop policies that ensure all government buildings invest in low-emission and efficient systems. Across the region, the procurement of efficient systems in public institutions is beginning to take hold, with the potential to become a clear requirement for new and ongoing system procurement.

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Stakeholders for sustainable appliances and systems

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

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

Table 14 • Stakeholder mapping for appliances and systems in Africa

National government	Subnational government	Utility companies	Property and project developers	Financial institutions	Architects and engineers	Manufacturers, retailers and suppliers*	Labourers and installers	Building owners and occupants	Civil society**

* of appliances and materials

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

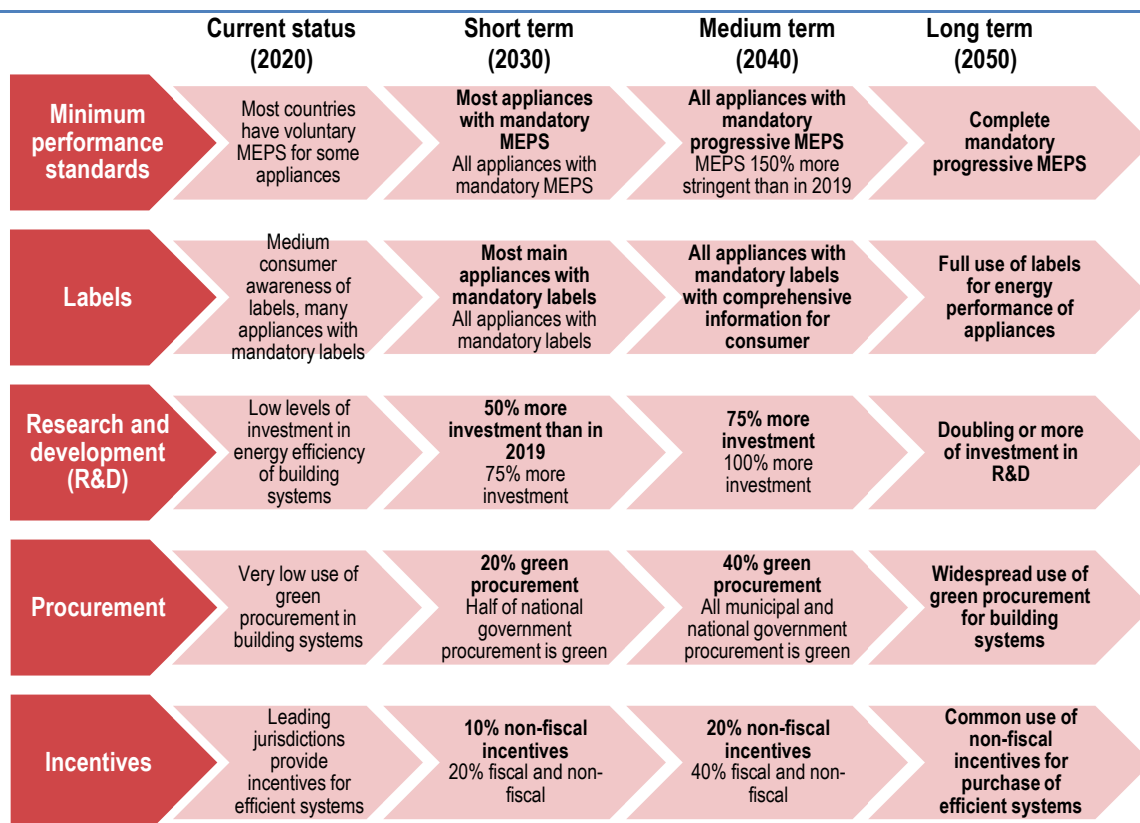
How to read: The darker the colour, the higher the impact that stakeholder group has on the activity and the more essential they are to delivering the roadmap targets.

Policy for sustainable appliances and systems

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

Within the targets for sustainable systems, the sub-targets and timelines in Figure 22 offer more details:

Figure 22 • Policy timelines for appliances and systems in Africa



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

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

- **Minimum performance standards:** Lighting, appliance and equipment products commonly have standards in many countries. These standards should be expanded to all countries and strengthened for higher performance requirements. Testing protocols and enforcement of MEPS are essential for MEPS to work effectively. Regional co-operation and harmonisation of standards could be particularly interesting for the subregions. 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) 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 of refrigerants and emissions of indoor air pollutants. All countries in the region may follow this shift. *Stakeholder feedback: Across the region there is a diversity of voluntary and mandatory MEPS for appliances with consensus that these could be implemented and be more widespread as soon as 2030.*

- **Labels:** Product labels on systems and appliances can provide information on the performance of the products including their embodied energy and carbon and their life-cycle energy and carbon performance. Support the information rollout with educational efforts to increase the capacity for people to make better design, purchase and operational decisions. *Stakeholder feedback: The current understanding of labels is limited, but there was a view that this will increase going towards 2040.*
- **R&D:** Increasing research funding can enable the invention of new products and services while also increasing the ability to get improved technologies to the market cost-effectively. *Stakeholder feedback: There was consensus that there is a limited amount of R&D funding, but that this would increase by 2040.*
- **Procurement:** Public and private entities can purchase sustainable products and services to support the effort to phase out the use of unsustainable products and services. This effort, which can be made by both public and private entities, can include bulk procurement or minimum performance specifications for procurement rules. The target in the timeline above refers to increasing shares of “green” procurement, which is procurement based on minimum specifications such as minimum energy efficiency and/or other environmental standards. *Stakeholder feedback: There was a view that there is a limited use of efficient goods in purchasing practices, but that this could increase in some countries in the region by 2040 and 2050.*
- **Incentives:** Non-financial incentives, such as expedited product approvals, should be the priority to encourage sustainable systems. Financial incentives should be used to enable the market development or purchasing of the very best sustainable systems, while finance support, such as loan guarantees, should enable private investment in sustainable systems. *Stakeholder feedback: There was a view that incentives may be used coming to 2040 to promote the purchasing of efficient goods.*

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

South Africa

In South Africa, mandatory MEPS compliance is required for most appliances including washing machines, dryers, dishwashers, refrigerators, ovens, water heaters, air conditioners, light bulbs and audio-visual equipment. The energy efficiency label uses the letter rating system. This provides South African consumers with accurate and comparable information on the energy efficiency of household appliances and equipment and encourages them to buy appliances that are more efficient. Labelling is mandatory for most appliances except light bulbs.

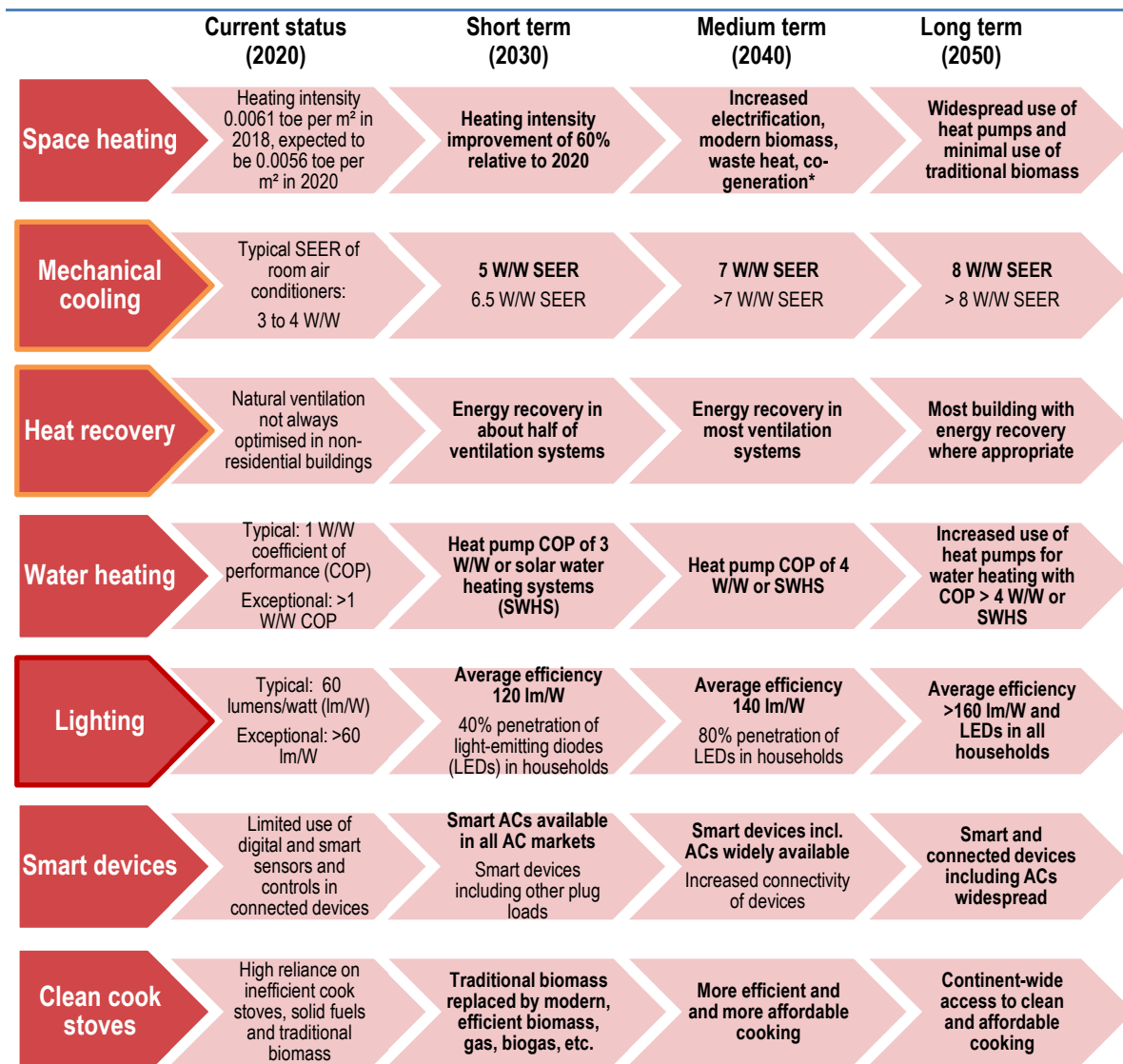
Cabo Verde – MEPS and label

The Decree-Law No. 25/2019 created the National Labelling System and Electrical Appliances Requirements establishing measures and obligations to inform the end user about energy consumption and minimum requirements in terms of energy efficiency equipment and appliances. The Cabo Verde Guarantee Label was also created; it can be placed only on new appliances with higher levels of efficiency, supporting consumer decision-making when purchasing new energy-consuming or energy-related products.

Technology for sustainable appliances and systems

Specific targets and timelines for the sustainable system technologies are outlined in Figure 23:

Figure 23 • Technology timelines for appliances and systems for Africa



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Notes: *Co-generation* refers to the combined production of heat and power. toe = tonnes of oil equivalent; ACs = air conditioners; SEER = seasonal energy efficiency ratio. The **proposed regional target** is in **bold**. Below that is the proposed accelerated target. A red border indicates an ambition gap for that target (more details below); an orange border indicates a gap in data or consensus (more details below).

Details on the technology targets for appliances and systems are outlined below.

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

- **Space heating systems:** Heating technology can enable more efficient delivery of space comfort through improved system efficiency. 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 co-generation. In Africa, heating intensity (in tonnes of oil equivalent per square metre of floor area) is one of the highest due to widespread use of biomass, despite heating needs being concentrated in northern African countries. The SDS will require improvements of over 60% by 2030 from 2020 levels (IEA, 2019b). Key technologies to achieve these reductions are heat pumps, clean district heating systems, and the phasing out of fossil fuels and traditional biomass. *Stakeholder feedback: Very few data were obtained regarding the evolution of heating efficiencies.*
- **[data gap] Space cooling systems:** 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 or cooling seasonal performance factor). Alongside appropriate design strategies that minimise the need for cooling, adoption of hybrid cooling methods, such as evaporative cooling, ventilative cooling and other “free cooling” that uses ground or water temperatures, can support the increased overall efficiency. Overall system efficiency will also increase with the use of variable speed drives and improved thermal distribution efficiency. Overall performance of the space cooling system is based on the efficiency of the cooling equipment and the thermal distribution system, such as ducts or pipes, to deliver the cooling within the building. *Stakeholder feedback: Very little information was provided as to the expected improvement of efficiencies of room air conditioners. The Future of Cooling by the IEA estimates that to accommodate the expected rise in cooling demand and stay on track of climate goals, global average efficiency of air conditioners will have to reach over 8 W/W SEER by 2050 (IEA, 2018).*
- **[data gap] Heat recovery:** To improve indoor air quality, controllable ventilation is essential. The three primary ventilation types include mechanical, natural and hybrid. To increase both the ventilation efficiency and energy retention efficiency, buildings can shift increasingly to hybrid ventilation, which uses natural ventilation when feasible and mechanical ventilation when natural ventilation is not effective. To further improve the efficiency, when in mechanical ventilation mode the system should include energy recovery ventilation technology to enable air exchange with minimal heat and humidity transfer. Energy recovery ventilation efficiency will also need to improve from low efficiency systems near 50% efficiency to high efficiency in the 80-90% efficiency range. *Stakeholder feedback: Very few data were obtained regarding the evolution of ventilation.*
- **Water heating systems:** Available heating technologies can enable more sustainable and efficient delivery of hot water through modern renewable energy sources and improved system efficiency. Efficient heat pumps, solar thermal water heaters, efficient modern biomass boilers, and the use of waste heat and co-generation offer effective solutions for decarbonising water heating. *Stakeholder feedback: Very few data were obtained regarding the evolution of water heating systems.*
- **[ambition gap] Lighting:** Lighting technology can enable more efficient delivery of visual comfort through improved lumens per watt efficiency. Lighting technology developments in more efficient solid-state lighting is improving the quality of light, efficiency and maintenance and reducing costs. Daylight harvesting systems with intelligent controls, sensors and shading devices can also support the target for increased lumens per watt. Reaching efficiencies of 160 lm/W and a 40% penetration of LEDs in the residential sector by 2030 globally is needed to meet the SDS (IEA, 2019b). *Stakeholder feedback: There was*

strong consensus that lighting efficiencies would reach only 100 lm/W to 120 lm/w by 2050, which is far below what is needed in the SDS.

- **Smart devices:** Ongoing digitalisation of electric appliances is unveiling new opportunities to improve resource efficiency and flexibility, and allow consumers to manage their consumption through demand-side response. Appliances such as air conditioners and other devices should increasingly be equipped with the capacity for smart or connected control. *Stakeholder feedback: There was a view that the take-up of sensors and controls will be widespread in residential buildings by 2040, but only about half in non-residential buildings.*
- **Clean cook stoves:** Switching to modern cooking fuels, such as gas and electricity, can significantly reduce indoor air pollution and promote health improvements, time and cost savings, and gender equality. Cleaner cooking fuels benefit the whole city, as household heating and cooking are also significant sources of outdoor air pollution (WRI, 2017). There is no single solution and various fuels can be used to improve clean cooking such as biomass, biogas, ethanol or LPG, depending on the local circumstances and cultural acceptability. Renewables technology will play an important role in scaling up the commercialisation of clean cooking systems.

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

- **Appliances:** Large and small appliances both have opportunities for increased sustainability. Development in appliance efficiency is needed to counter the surge in appliance usage from rising wealth and ownership. The most significant gains have been in refrigerators, with specific targets noted above, where increased efficiency continues through variable speed compressors, improved insulation and heat pump technologies. Other appliances such as dishwashers, clothes washers and dryers, televisions, and digital appliances will need to become more efficient, and reduce standby losses and connectivity energy use through sensors, controls and automation to enable low power modes, load balancing, demand response and remote programming.
- **Energy storage:** Thermal energy storage for heating or cooling can enable load shifting, optimised heat transfer efficiency and integration with renewable energy, which will become ever more important with growing electrification and pressure on peak demand. Thermal energy storage systems can take the form of highly insulated water or refrigerant tanks, thermal mass, or phase change materials. Current research is focused on reducing the costs, increasing 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.

Box 16 • Regional examples of action on systems technology

Southern African Development Community – Regional

The South African Power Pool promotes demand-side management programmes to reduce consumer energy demand by methods such as replacement of incandescent bulb with LEDs and compact fluorescent lamps, installing solar water heaters and prepaid meters, and conducting awareness campaigns, saving 4 500 megawatts (MW) in four years, with the greatest savings from efficient lighting, accounting for three-fourths of the savings.

Electric cooking – regional

Modern Energy Cooking Services ([MECS](#)) is a research and innovation programme focused on how to enable the world's 3 billion people who still cook with biomass to transition to clean cooking solutions, such as electricity or gas. Among its main activities, the programme will create a Challenge Fund for funding alternative solutions to

the use of traditional biomass fuels and develop new technologies to make electric and gas cooking appliances more efficient, practical and affordable for poorer households.

A study by MECS in Nairobi, Kenya, involved 20 families recording what they cooked, how they cooked it and how much energy they consumed for two weeks. These families then experimented with a variety of electric cooking utensils for four weeks. The energy consumed during these different cooking processes was measured to identify waste and savings in order to demonstrate the implications of switching to electric cooking, such as saving time and money and still preparing tasty food.

Uganda

The [Uganda Standard for energy efficient stoves](#), from 2007, specifies the performance and test methods for household biomass stoves in order to promote a smoke-free environment, cost savings and reduced cooking time. The household stoves covered in this standard utilise biomass fuels, namely charcoal, wood, bagasse, husks, plant shells and any other biomass.

Finance for sustainable appliances and systems

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

Financial tools particularly relevant to appliances and systems include:

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

Capacity building for sustainable appliances and systems

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

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

Table 15 • Capacity building for appliances and systems in Africa

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

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

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

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


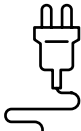


Further details regarding capacity-building activities are provided in the section “Roadmap support: Enablers”.

Multiple benefits of sustainable appliances and systems

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

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

Table 16 • Multiple benefits of sustainable appliances and systems

Environment	
	<ul style="list-style-type: none">• Emissions reductions – sustainable appliances and systems deliver GHG reductions through lowered energy consumption.• Air quality – sustainable appliances and systems reduce air pollution through lower on-site emissions and lowered energy consumption.
Energy	
	<ul style="list-style-type: none">• Energy savings – sustainable appliances and systems are more energy-efficient.• Energy security – sustainable appliances and systems use less energy and put less strain on energy systems.• Energy prices – sustainable appliances and systems reduce energy demand and peak loads, which can lower network infrastructure and system costs.
Economy	
	<ul style="list-style-type: none">• Productivity – sustainable appliances and systems can increase the productivity of students and employees through improved thermal comfort, lighting and noise.• Asset value – sustainable appliances and systems can improve the asset value of buildings.
Society	
	<ul style="list-style-type: none">• Poverty alleviation – sustainable appliances and systems reduce building operation costs.• Health and well-being – sustainable appliances and systems deliver increased thermal comfort and light, noise and indoor air quality, improving physical and mental health and well-being.• Safety and security – sustainable appliances and systems can include features such as building automation, sensors and lighting, as well as features to improve and facilitate maintenance, which can prevent system failure.

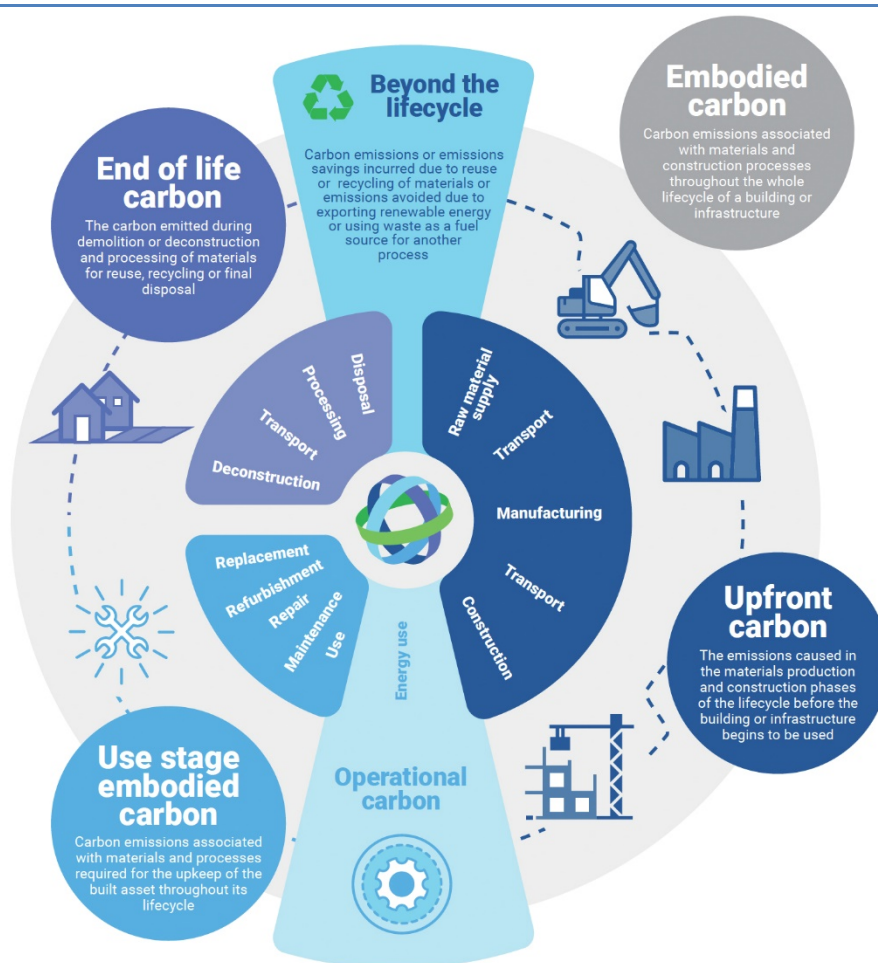


Activity 6: Materials

Construction activity in the buildings sector generates a major flow of materials in every country. The construction and demolition of buildings accounts for around one-third of global material consumption and waste generation. GHG emissions or energy consumption are linked to every phase of the life cycle of materials, from extraction or harvesting to manufacture, transport, construction, use and demolition. For instance, steel, cement bricks and non-certified wood (deforestation issue) are some of the major building product emitters of CO₂.

Embodied carbon is the sum impact of all the carbon emissions attributed to the materials throughout their life cycle (extracting from the ground, manufacturing, construction, maintenance and end of life/disposal), as shown in Figure 24 below.

Figure 24 • The World Green Building Council’s (WorldGBC’s) scope and definition of the building life cycle



Source: WorldGBC (2019), “Bringing embodied carbon upfront: Co-ordinated action for the building and construction sector to tackle embodied carbon”.

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

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

Globally, cement and steel are two of the largest sources of building material-related CO₂ emissions. Total cement production is responsible for around 7% of global CO₂ emissions, with steel contributing 7-9% of the global total, of which around half can be attributed to buildings and construction (WorldGBC, 2019).

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

Wood, if appropriately managed, could lower CO₂ emissions greatly. Studies show that “between 14% and 31% of global CO₂ emissions could be avoided by preventing emissions related to steel and concrete; by storing CO₂ in the cellulose and lignin of wood products; and other factors”. Lighter than iron and steel or cement, wood constructions require less material to support the structure and in turn lower the demand for materials, creating a virtuous circle (Oliver et al., 2014). This will in turn reduce energy demand for transport (of the materials) and assembly. For the moment, current policies do not address most of the potential of wood construction, and even if a large upscaling would require careful planning to prevent negative effects from deforestation, if countries with current low industrialisation levels also make the transition, even 90% of buildings could be constructed using timber (Churkina et al., 2020).

Box 17 • Materials in Africa: Trends and challenges

A high construction rate due to increasing population and economic growth has led to more demand for construction materials, increasing the energy consumption and CO₂ emissions from material production. The first step towards mitigating this issue is to reduce the dependency on raw materials by reducing material use, reusing materials or using recycled materials. These materials have lower embodied energy and carbon.

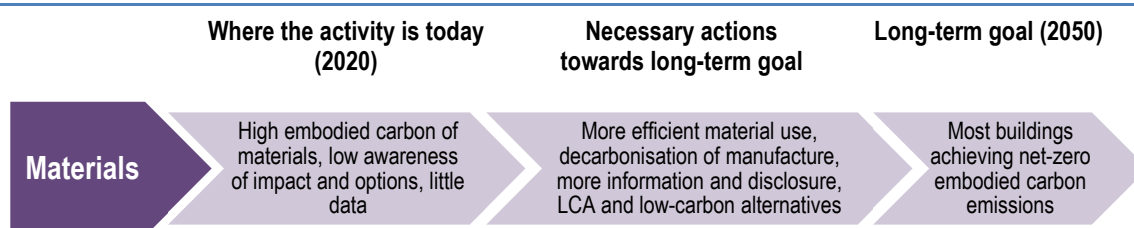
Many African countries have large resources of local materials for construction, but these are still seen as inferior, or there seems to be a lack of knowledge on how to use them to their full potential.

Traditional materials and designs look set to play an important role in Africa, and so do local innovations. For example, a Colombian company has exported its manufacturing experience of producing bricks from used plastics to Cote d'Ivoire, where the aim is to build 500 classrooms using this technology by 2020. As well as mitigating the growth of cement and steel demand, an approach tailored to African conditions would help promote a housing stock suited to the climate, which in turn would act to offset some of the growth in demand for cooling. New initiatives could bring about urbanisation with reduced resource needs. Adobe houses and bamboo- or wood-based low-storey buildings are examples of what may be possible in this context.

In Africa, very few countries have mandatory or voluntary standards for construction materials. This includes mostly physical properties of the material. The embodied energy or carbon is not the main consideration. Hence, there exists a great potential to push for material efficiency in this region. This requires combined effort from the government, industry and the research community.

Key actions for sustainable materials

Figure 25 • Key actions for materials in Africa



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

- **Collect data** on embodied carbon of building and construction materials; develop a database that can be accessed by all relevant stakeholders and that allows comparisons and calculations. Develop guidance on the use of methodologies and standards for making calculations and assessments.
- **Provide information and raise awareness.** Promote capacity on low-carbon materials and technologies (e.g. wood and earth constructions, innovative concrete) among professionals involved in the building design and construction process. Provide tools, training and capacity building; conduct or commission research into low-carbon materials and approaches. Carry out or commission case studies to convey the benefits of use of low-carbon materials and raise awareness.
- **Integrate considerations of embodied carbon in planning and building regulations.** Require disclosure for all new construction and for large renovation projects, initiate low-carbon materials pilot projects, provide incentives to property and project developers.
- **Accelerate energy efficiency in manufacturing.** Develop measures to effectively speed up the implementation of energy efficiency in industries that manufacture building and construction materials. Promote energy management, develop best practice guides and support the adoption of BATs. Include building material manufacturing industries as part of demand-side management efforts.
- **Stimulate markets for low-carbon products and materials.** Implement policies that enable improved design and purchasing decisions based on embodied carbon and energy. This could be achieved combining push levers, such as carbon pricing, tax incentives, subsidies and regulations on production of materials, with pull levers, such as public procurement and regulations on the construction sector. Develop policies that ensure all government buildings invest in low-carbon and efficient materials based on LCAs.
- **Require embodied carbon assessments** or LCAs to be undertaken on all new major and public investments, disclose portfolio and/or asset-level embodied carbon emissions, provide financial products to incentivise low-carbon projects and business models, provide preferential loans or mortgages to stimulate a market for low-carbon materials.
- **Reduce demand.** Develop approaches for lowering the demand for building and construction materials through design briefs and construction approaches that reduce the need for added materials. This in turn will help to **reduce extraction** of key natural resources, e.g. sand for building materials.
- **Reuse and recycle.** Develop strategies for repurposing of buildings when appropriate. Mandate plans and systems for collection and reuse/recycling of construction and demolition waste. Improve deconstruction processes including via the development of guidelines or protocols for deconstruction and selective sorting of waste.
- **Support the development of material reuse and recycling processes** for products and materials that can reduce the life cycle of embodied energy and emissions⁹ and **increase the use of repurposed materials** in product manufacturing and in building and construction projects.
- **Promote circular economy.** Develop cradle-to-cradle life-cycle approaches in the buildings sector to enable a systemic, material-neutral and performance-based approach and business model. Integrate whole-lifecycle carbon thinking into planning and design processes.

⁹ This has to be set cautiously as some materials can be reused only if the adequate processes are in place during the demolition phase (recovering un-hydrated cement can be achieved only if carefully designed processes are used to crush the concrete and separate the different constituent materials).

Stakeholders for sustainable materials

In Africa, the key stakeholders for sustainable materials include those that can influence materials and those that can deliver the results of zero-emissions, efficient and resilient buildings through use of sustainable materials.

Additional stakeholders include those that can support the process through research, funding and training.

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

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

Table 17 • Stakeholder mapping for materials in Africa

National government	Subnational government	Utility companies	Property and project developers	Financial institutions	Architects and engineers	Manufacturers, retailers and suppliers*	Labourers and installers	Building owners and occupants	Civil society**

* of appliances and materials

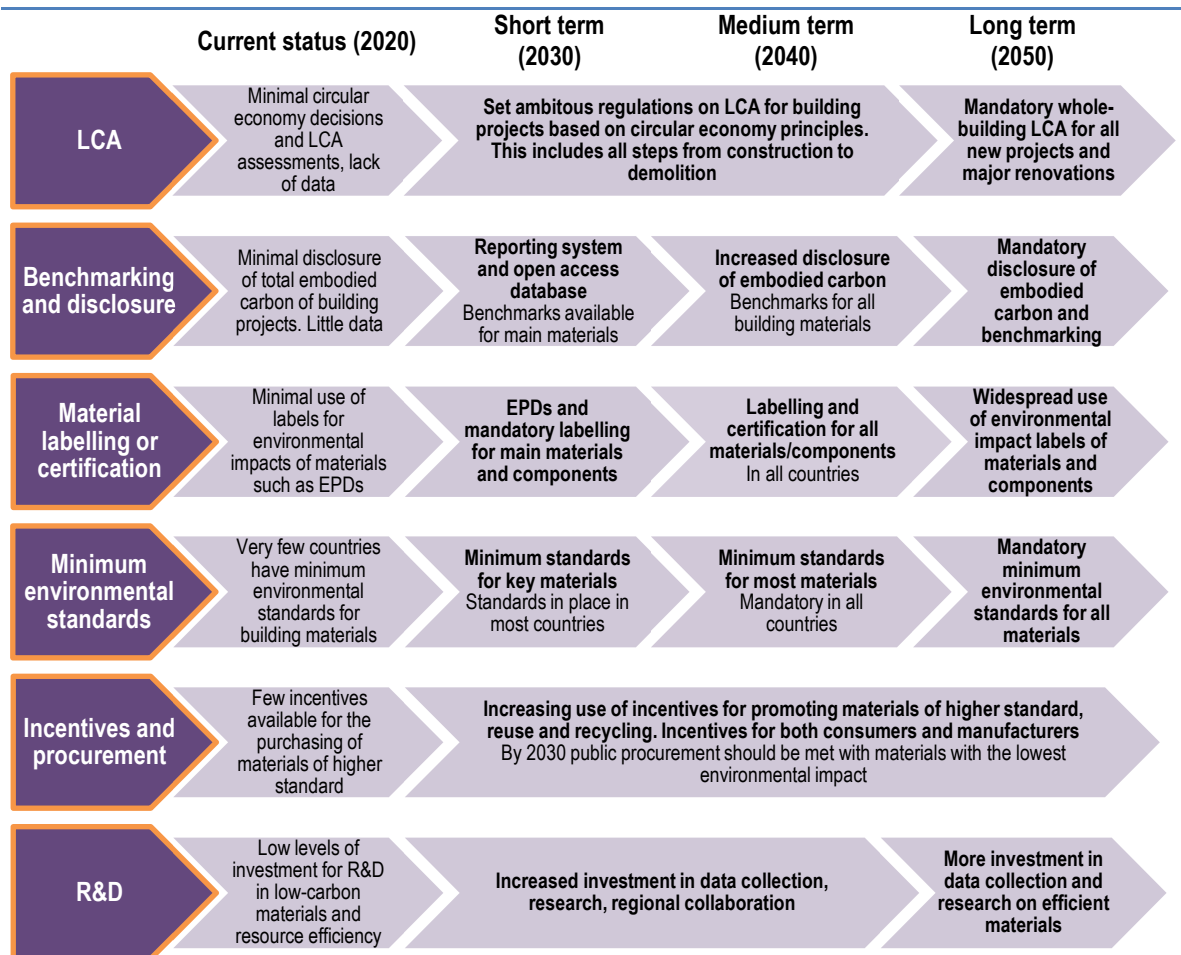
** including academia, NGOs, research institutions, social networks and community associations.

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

Policy for sustainable materials

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

Figure 26 • Policy timelines for materials in Africa



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Notes: EPDs = environmental product declarations. The **proposed regional target** is in **bold**. Below that is the proposed accelerated target.

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

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

from construction to demolition. In particular, plans on how waste will be reduced and managed should be established as early as possible in projects. A waste management plan reduces the construction and demolition waste that are usually disposed of in landfills or incinerated by providing options to recover, reuse or recycle the materials.

- **[data gap] Benchmarking and disclosure:** In order to monitor progress, understand best practices, and to facilitate better decisions at the design stage and in policy-making, benchmarking coupled with data disclosure will be of importance. Data disclosure requirements could build on experiences with material passports¹⁰ and other initiatives such as the Carbon Disclosure Project.¹¹ Disclosure of the environmental impacts and efficiency levels of building projects should be developed in order to ensure a better enforcement of regulations.
- **[data gap] Material labelling:** Product labels on materials can provide information on the sustainability of the products, including their embodied energy and carbon and their life cycle energy and global warming potential. Supporting the information rollout with educational efforts to increase the capacity for people to make better design, purchase and operational decisions. EPDs and Health Product Declarations are some of the different labelling systems available currently. Disclosure of the environmental impacts and efficiency levels of the building projects should be developed in order to ensure a better enforcement of regulations.
- **[data gap] Minimum environmental standards:** The creation of EPDs for building and construction materials and products and their use in design is voluntary in most regions and countries. Some European countries, such as Finland, France and the Netherlands, are moving towards legislative adoption of LCA requirements for the construction industry, which is expected to be a catalyst for wider market penetration of EPDs (WorldGBC, 2019). The successive development and expansion of voluntary schemes towards mandatory minimum environmental standards for materials would effectively create markets for low-emission products. Testing protocols and standards for materials (including new materials) will have to be developed. Building codes, where in place, should include minimum environmental performance standards for materials to be used or via performance requirements encourage use of low-carbon materials. Stringency should be increased over time to continue to drive the market further towards low-carbon solutions.
- **[data gap] Incentives:** Financial incentives should be used to drive markets towards sustainable materials, while financial support, such as loan guarantees, should enable private investment in sustainable materials. Incentives should therefore address both consumers and manufacturers of sustainable materials. These incentives will drive, as well as rely on, procurement strategies. Purchasing sustainable products and services, which should be done by both public and private entities, can include bulk procurement or minimum performance specifications for procurement rules. Public procurement should also include requirements for minimum recycled content and reusability or recyclability. Financial incentives should also be used to support new construction techniques that lower embodied carbon. Disincentives can also be used to penalise the use of particularly unsustainable materials, such as those responsible for unsustainable sand extraction.

¹⁰ Material passports include data on all the materials that are included in a construction and which provide information on characteristics and highlight the potential for reuse and recycling.

¹¹ The Carbon Disclosure Project is a voluntary global system for investors, companies, cities, states and regions to manage their environmental impacts.

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

Box 18 • Regional examples of policy action on materials

Namibia

The Ministry of Urban and Rural Development of Namibia established the Habitat Research Development Centre (HRDC). Its mission is: “To promote use of local, indigenous building materials and designs, to engage multi-disciplinary teams in basic research, the adaptation of existing knowledge and applied research to achieve a holistic approach to problem solving in the field of housing and its related issues”. The building of HRDC was designed for energy efficiency and occupant comfort. Recycled materials and indigenous materials such as rammed earth and insulation made of low-grade sheep’s wool have been used for construction (Tessema, Taipale and Bethge, 2009).

Kenya

The Ministry of Land, Housing and Urban Development in Kenya set up Appropriate Building Materials and Technology (ABMT) with 1 regional, 9 subregional and 73 subnational ABMT centres across the country. The objective of ABMT is to “facilitate/coordinate collaborative research and documentation; technology incubation and enterprise development; and technology transfer, capacity building training and dissemination to facilitate efficient and cost-effective housing delivery”

The ministry is promoting the technology of interlocking stabilised soil blocks under the programme as it uses local material, reduces construction costs and creates sustainable employment (State Department of Housing and Urban Development, Kenya, n.d.)

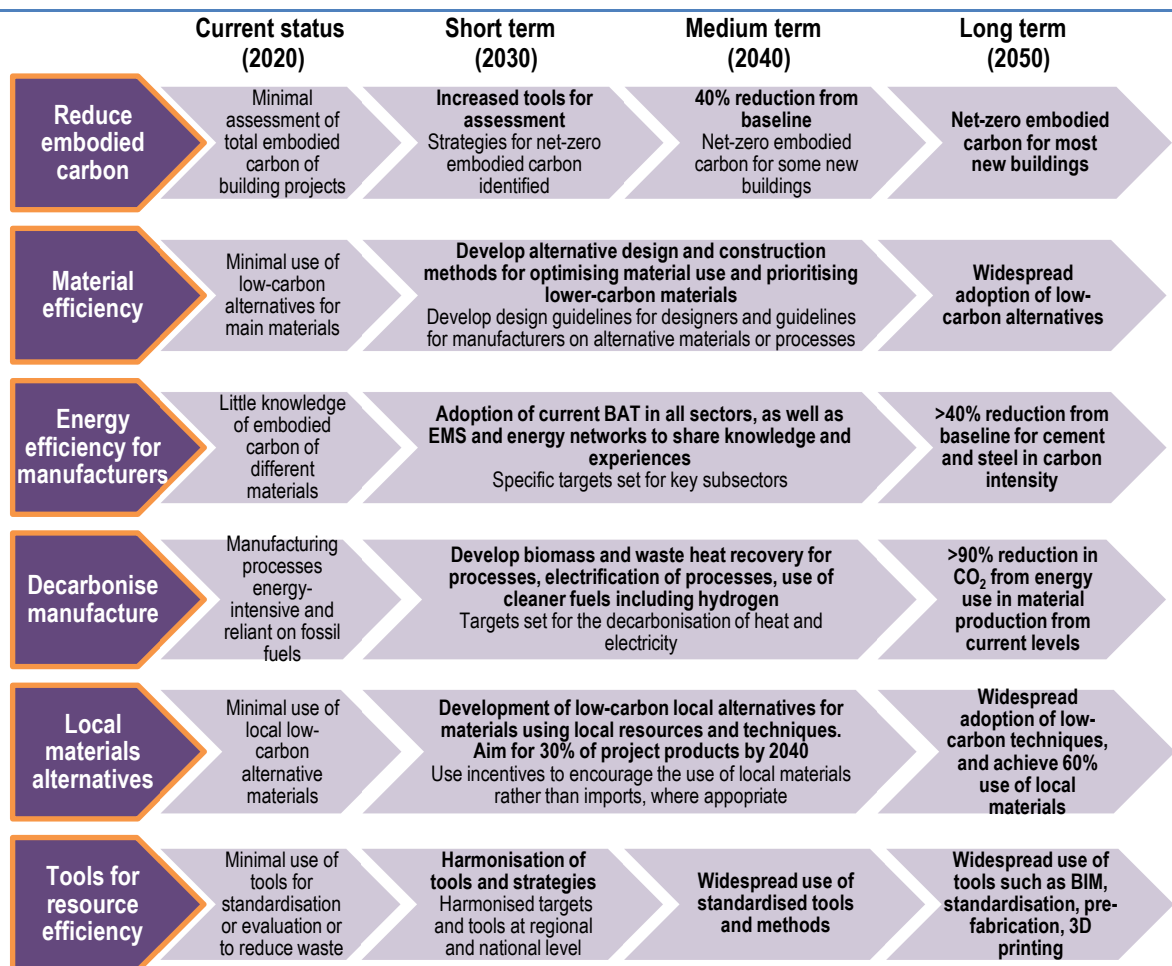
Regional

The [Clay Brick Association](#) of Southern Africa has implemented a full LCA of its materials and performance in buildings. It has also implemented measures to mitigate carbon emissions in brick manufacturing processes, such as encouraging the upgrade of old manufacturing plants, and has established a sustainability desk to address mitigation and support implementation and engagement across both the formal and informal sectors.

Technology and strategy for sustainable materials

Specific technology targets and timelines for sustainable materials are outlined in Figure 27:

Figure 27 • Technology timelines for materials in Africa



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

Details on the technology targets for building materials are outlined below.

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

- **[data gap] Reduce embodied carbon**: Develop a strategy to decarbonise building materials and set targets for overall embodied carbon/energy of building projects and EPDs. This strategy will need to rely on comprehensive data collection efforts and the development or adaptation of standardised tools and benchmarks to assess embodied carbon and set performance targets of reduction over baseline over time. Specific targets should be set for

the subsectors and in particular for the major materials used such as cement and steel, while promoting low-carbon and nature-based solutions for building materials.

- **[data gap] Material efficiency:** Reducing primary material demand through optimised design, optimised building techniques, the more intensive use of existing materials and the reuse of scrap material 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 in order 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).
- **[data gap] Energy efficiency in material production:** For all materials, indicators to monitor specific energy use for their production should be established, tracked and compared with BATs. This will allow manufacturers to set targets and minimum standards. Current BATs should be promoted across all sectors. Further measures to improve energy efficiency include making EMS (such as the ISO 50001) compulsory, promoting industry networks (to share best practices, identify energy efficiency potentials, set targets, etc.), and promoting access to and uptake of sustainable manufacturing technologies.
- **[data gap] Decarbonising materials manufacture:** 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, or 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. There are currently few pilots to explore ways to decarbonise the heavy industry.¹² With the rate of increase in demand for materials in India, for instance, there could be an opportunity to develop a new industry based on the most advanced technology.
- **[data gap] Locally produced low-carbon materials:** Promote the development of local industry for the production of building materials where appropriate as determined by an LCA. This will of course have to be paired with new building methods linked with new materials (construction with timber or bamboo will require capacity building and process development) and promotion of building examples. This should be done at regional level so that this new industry has a larger market and is able to make more investment (again, supported by regional bodies), leading to benefits to jobs and local industry.
- **[data gap] Tools for resource efficiency:** Measures should be taken to reduce manufacturing waste, develop materials and products that require fewer resources, and develop projects that require fewer material inputs. At the design stage: reducing oversizing and encouraging structural optimisation (such as lightweighting, drywall, etc.) may enable using fewer materials to provide the same service, as could, for instance, the use of precast concrete material, the development of 3D printing, prefabrication, BIM, modularity of buildings, etc.

¹² The Swedish initiative HYBRIT for steel manufacturing and the Norwegian project in Brevik for cement are to be noted as examples of pilots across the world trying to reach net-zero carbon emission manufacturing.

Box 19 • Regional examples of action on technology for sustainable materials

Timber beam and sandbags in South Africa

The buildings made from timber beam and sandbags that originated in South Africa are gaining popularity in the region due to their low cost and low environmental effects. The structures also have good thermal properties and are waterproof, fireproof and soundproof. A wooden framework is filled with sandbags and then plastered. The National Home Builders Registration Council approves of this method (Stemmett, 2020).

Promoting Nubian Vaults in West Africa

The [Nubian Vault Association](#) (AVN) is an organisation established in 2000 that works towards construction of affordable homes in West Africa. Nubian Vault is a very old construction technique originally from Sudan and central Africa that uses local mud bricks for construction. This type of construction has a very low carbon footprint and reduces the cost of construction and maintenance by 50-60% compared with homes built using concrete or metal. The thick walls also have natural insulating properties, thus keeping the houses cool during summers and warm in winters. According to AVN's 2017/18 annual report, 495 private and community buildings were constructed in the year covering a total built area of 104 000 m². AVN is not only making housing affordable but is also supporting the economy by providing training and creating new jobs in the community (The Nubian Vault, n.d.).

Locally produced clay bricks in Tanzania

The Mwanza Rural Housing Programme trained people from 70 villages to produce brick from local clay in a more environment-friendly way. While the traditional method used wood for firing the bricks, the programme introduced the use of agricultural residue such as rice husk, cotton or coffee waste for firing construction. The net carbon emissions due to burning agricultural residue is zero (Tessema, Taipale and Bethge, 2009).

Finance for sustainable materials

Financial tools particularly relevant to sustainable materials may include:

- **Urban development funds:** Dedicated funding for urban development projects, which can prioritise sustainable urban development projects.
- **Infrastructure funds:** Dedicated funding for infrastructure projects, which can prioritise sustainable infrastructure projects.
- **Dedicated credit lines:** Funding delivered through banks for a specific purpose, which can prioritise sustainable buildings, construction or development projects. Dedicated credit lines to national or local governments can also be used to establish a revolving loan fund, which collects repaid loans for energy efficiency projects and reinvests them in additional energy efficiency projects.
- **Preferential tax:** Direct funding from the government to reduce or eliminate taxes for sustainable products and services.
- **Carbon pricing:** In order to facilitate the uptake of materials with low embodied carbon, a carbon price, agreed at regional level, could be carefully implemented for the medium term. This will be particularly relevant for cement and steel, which are heavy low-value products and hence would be less affected by large-scale competitiveness problems. It would encourage materials efficiency, reuse and recycling; promote R&D for alternative solutions; and promote the decarbonisation of materials.
- **Grants and rebates:** Direct funding to overcome upfront cost barriers, provided by a government, organisation or programme either through a competitive process (grants) or during or after the purchase of a sustainable product or service (rebates).
- **Procurement purchase and lease:** The purchase or lease of sustainable products and services. Leasing enables the use of energy-efficient products on a rental basis to overcome high upfront costs or capital-intensive investments.

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

Capacity building for sustainable materials

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

The types of capacity-building activities relevant to materials are mapped in Table 18, where the darker the colour, the higher the impact that capacity-building type has for this activity.

Table 18 • Capacity building for materials in Africa

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

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

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

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





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

Multiple benefits of sustainable materials

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

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

Table 19 • Multiple benefits of sustainable materials

Environment	
	<ul style="list-style-type: none">• Emissions reductions – sustainable materials reduce embodied carbon emissions in building and construction through lowered energy consumption in manufacturing.• Air quality – sustainable materials can improve indoor air quality because of lower pollutants, and can improve outdoor air quality through lowered combustion and cleaner manufacturing processes.• Resource efficiency – sustainable materials improve the resource efficiency of the manufacturing and construction of buildings through increased resource recovery, reuse and recycling across the supply chain.
Energy	
	<ul style="list-style-type: none">• Energy savings – sustainable materials can deliver energy savings in both the manufacturing process and the operation of buildings.
Economy	
	<ul style="list-style-type: none">• Economic performance – sustainable materials can boost economic performance as the circular economy turns waste streams into new resource streams.
Society	
	<ul style="list-style-type: none">• Poverty alleviation – producing materials locally and training local populations can boost local economies.• Health and well-being – sustainable materials can be more natural, and less toxic.



Activity 7: Resilience

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

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

Cities are increasingly using resilience frameworks to deal with climate change impacts because resilience planning inherently requires a holistic approach and considers both expected and unexpected events. However, resilience is a wide-ranging and complex concept that is often difficult to operationalise and sustain, and encompasses a great diversity of stakeholders from local communities to city authorities to building construction companies.

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

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

Box 20 • Resilience in Africa: Trends and challenges

The effects of climate change in Africa are varied across the continent's diverse environments and climates. They include changing temperatures, more intense storms and rainfall, more extreme and unpredictable weather, and increased occurrence of drought (ActionAid, 2016) with notable effects on hydropower generation and water availability. UN Habitat emphasises that climate change presents an acute threat for African cities, as many large cities are located in coastal areas and are directly vulnerable to rising sea levels, saline penetration, storm surges, flooding and coastal erosion (UN-Habitat, 2014). Such adverse environmental conditions are also likely to increase migration to urban areas, as rural populations will suffer climate impacts with few alternative economic opportunities.

A growing body of evidence shows that disaster risks in African towns and cities are strongly linked to underdevelopment. Precarious livelihoods combined with a lack of access to basic infrastructure such as water and waste management, deficient urban and land planning, and inadequate land-use and building standards all exacerbate the exposure and vulnerability of poor households to hazards. Reducing risk and strengthening building resilience to disasters in urban areas is closely related to underlying developmental issues. Therefore, it is essential to improve infrastructure and services and strengthen livelihoods, all of which are critical in reducing exposure to hazards and enhancing people's ability to cope with and recover from disasters (ActionAid, 2016).

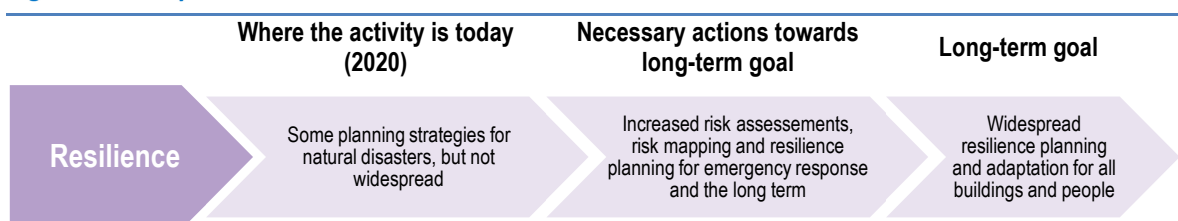
African cities are vulnerable to a variety of climate change impacts, ranging from gradual shifts in temperature, heavy rainfall, rising sea levels, and coastal erosion to increases in the frequency and/or severity of extreme events, such as fires, floods, heatwaves and storm surges. Slum and informal-settlement dwellers often live in high-risk urban locations such as marginal land and lack access to basic infrastructure and services to withstand the effects of climate change. In addition, high levels of urban poverty exacerbate urban dwellers' vulnerability to economic, political and environmental changes, especially those affecting household living costs (e.g. increases in food and fuel prices) and damaging household assets (e.g. large storms and heavy rains) (Taylor and Camaren, 2014).

A growing number of African cities such as Accra, Lagos, Kigali, Dakar and Cape Town are integrating resilience in their planning frameworks, which can be used as examples by other cities across the region, supported in part by international organisations such as UN Habitat, 100 Resilient Cities, ActionAid and a number of humanitarian partners among others. Many municipalities, including those in Cape Town and Durban (South Africa), St. Louis (Senegal), Maputo (Mozambique), Dar es Salaam and Arusha (Tanzania), Kisumu and Nairobi (Kenya), Bujumbura (Burundi), and Kigali (Rwanda), have also joined the United Nations Office on Disaster Risk Reduction's ["My City Is Getting Ready" campaign](#). This initiative holds mayors accountable for strengthening their city's resilience to climate change (ActionAid, 2016).

However, one of the main challenges that the region faces is the lack of institutional capacity, as well limited resources, both financial and human. However, governments are increasingly acknowledging the importance of risk reduction to enhance resilience. It is now urgent for them to build the necessary capacity so that this aspect is taken into account across the multiple political plans. Information and awareness campaigns will also be crucial to face this disconnection between the perception and the urgent need to have a resilient buildings and construction sector.

Key actions for resilience

Figure 28 • Key actions for resilience in Africa



Key actions to enable increased resilience of buildings include:

- **Urban planning and risk zoning.** Use data and information to document the potential risk exposure by location to enable improved decision-making during the building and infrastructure design process. Identify areas of high growth and make planning frameworks that integrate climate risk assessment.
- **Wind- and seismic-resistant construction.** Implement policies and encourage best practice design and construction processes to enable buildings to be resistant to natural disasters and extreme weather events.
- **Storm-water management.** Require improved retention of storm water within properties to reduce the negative impact of water flowing to other properties and to surging waterways. Identify existing and new development areas and their impact on storm water, especially areas with heavy seasonal rains.
- **Thermal-resistant construction.** Implement policies and use best practice design to increase the resistance of buildings to extreme temperature and moisture. Support local building practices to reduce heat exposure and increase thermal mass. Make use of appropriate ventilation strategies.
- **Develop integrated assessment frameworks.** Work across governments and stakeholders to develop assessment plans that help to ensure resilience plans are holistic across jurisdiction and agencies.

Box 21 • What is a resilient city?

The [Sendai Framework for Disaster Risk Reduction 2015-2030](#) defines resilience as “the ability of a city exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions” (UN ISDR, 2015).

The discontinued [100 Resilient Cities Initiative](#) of the Rockefeller Foundation laid out a City Resilience Framework: “The capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience” (The Rockefeller Foundation and Arup, 2015).

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

Stakeholders for resilience

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

These stakeholders are mapped in Table 20, where the darker the colour, the higher the impact that stakeholder group has on the activity and the more essential it is to delivering the roadmap targets.

Table 20 • Stakeholder mapping for resilience in Africa

National government	Subnational government	Utility companies	Property and project developers	Financial institutions	Architects and engineers	Manufacturers, retailers and suppliers*	Labourers and installers	Building owners and occupants	Civil society**

* of appliances and materials

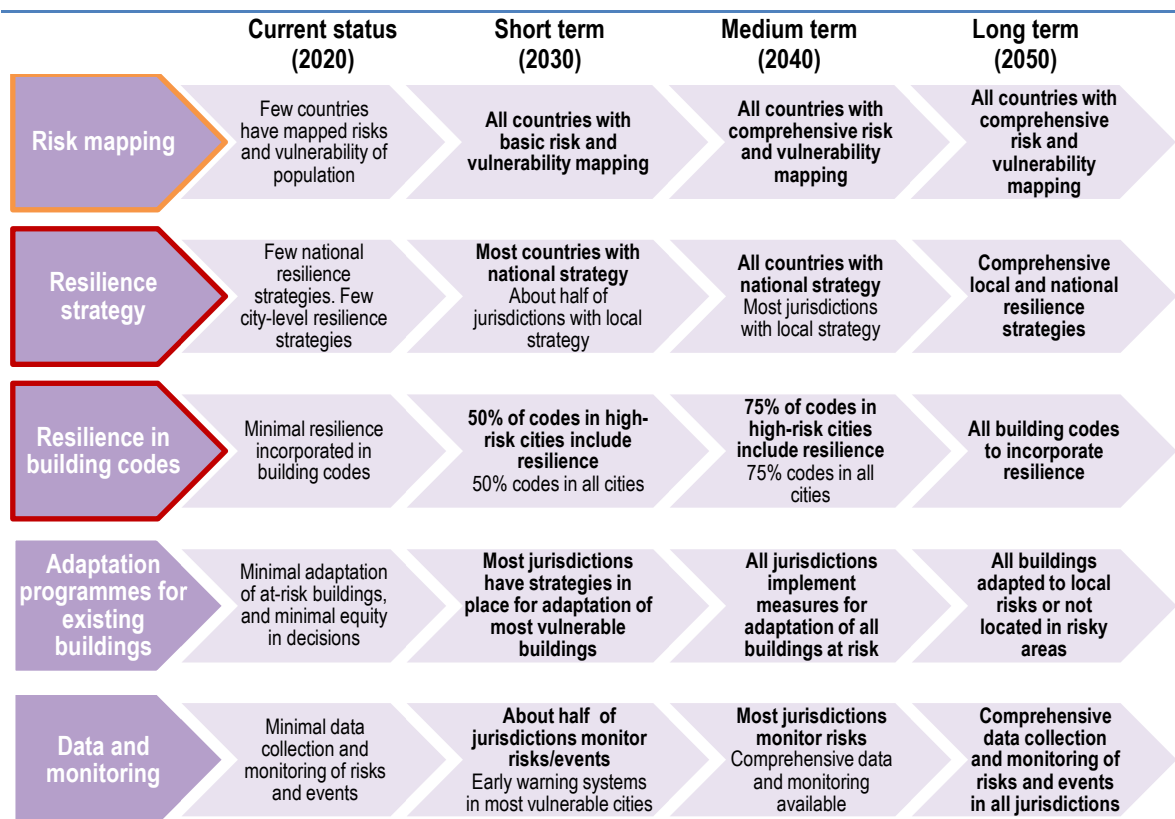
** including academia, NGOs, research institutions, social networks, and community associations

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

Policy for resilience

Within the targets for sustainable building resilience, the sub-targets and timelines in Figure 29 offer more details:

Figure 29 • Policy timelines for resilience in Africa



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

Details on the policy targets for building resilience are outlined below.

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

- **[data gap] Risk mapping:** Gather and document data related to: land-use plans incorporating natural hazards (e.g. landslides, earthquakes) and climate-related risks (e.g. flooding, heatwaves), emergency plans, existing community plans, ordinances and codes, maps and data on geographic location of critical infrastructure systems or facilities, community utility needs (e.g. energy, water and fuel use and generation), and climate preparedness plans. Many countries across Africa face the challenge of collecting and accessing timely and accurate data. For example, 14 African countries are taking on this challenge, notably by adopting open data policies through initiatives such as the [Open Government Partnership](#), which provides policy frameworks for public access to data,

along with a few local governments such as [Sekondi-Takoradi, Ghana](#); [Elgeyo Marakwet, Kenya](#); [Kaduna State, Nigeria](#); and [Kigoma-Ujiji, Tanzania](#). The online platforms that allow public access to data are also internally beneficial in improving access to data within these governments. Another important mechanism of risk mapping is participatory, or DIY (“do it yourself”), mapping such as [OpenStreetMap](#) and [Spatial Collective](#).

- **[ambition gap] Resilience strategy:** Develop a resilience strategy that identifies the list of policies and measures that can support increased resilience in an integrated manner, and addresses the potential for relocation and crisis plans for high-risk settlements. The development of resilient strategies requires stronger urban planning and regulatory capacity. A key dimension of resilience planning lies in identifying and enforcing protective mechanisms, such as local ordinances and by-laws that prevent development and buildings construction in hazardous locations, and mandate resilience standards in building and infrastructure construction (ActionAid, 2016). Resilience strategies should also include requirements for “building back better” during reconstruction after a disaster. All countries should develop national resilience strategies, and all jurisdictions should develop local resilience strategies. *Stakeholder feedback: Consensus was that there are currently very few cities with resilience strategies in place, and it appears to be uncertain whether these would become more adopted.*
- **[ambition gap] Resilience in building codes:** Include policies on land-use regulations such as development setbacks, which clearly distinguish where urban development cannot occur and identify where buildings should locate their lowest habitable floor; and regulations that require flood-proofing and retrofitting of at-risk buildings. 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. *Stakeholder feedback: Consensus was that currently very few building codes include resilience elements, and it appears to be uncertain whether these would become more adopted.*
- **Adaptation programmes for existing buildings:** In many cities, existing buildings in informal settlements are located on sites at high risk from floods or landslides or from other risks (for instance on unstable landfills) because the risks make them unattractive to developers. Upgrading informal settlements is particularly challenging because of the high degree of informality, and in order to change communities as a whole, rather than isolated projects, commitment from national and local governments is particularly important. Community members should be involved in the planning and implementation of resilience urban upgrading schemes to enhance their understanding of risks and harness their knowledge of the environment in which they live. A number of recent initiatives driven by NGOs such as [Slum Dwellers International](#) are showing the importance of engaging local communities and “[embracing informality](#)” by supporting self-built, incremental slum upgrading of housing and services (Dobson, 2017).
- **Data and monitoring:** The Sendai Framework includes a specific target dedicated to “[s]ubstantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to the people by 2030” (UN ISDR, 2015). Several initiatives, often led by grassroots organisations, use a combination of satellite imagery and community-led surveys to map and analyse the profile of specific neighbourhoods and informal settlements. Settlements are mapped using plane table methods that show plot boundaries. Spatial and socio-economic data are then entered

into a GIS database. Using this information, municipal governments and communities are able to prepare upgrading and resilience plans by widening roads, installing flood protection and building new infrastructure.

Box 22 • Regional examples of policy action on resilience

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Regional

The CityRAP Tool developed by DiMSUR (Technical Centre for Disaster Risk Management, Sustainability and Urban Resilience) uses participatory methodology and simple resources to collect data. It also trains municipal technicians to plan actions aimed at reducing risk and building resilience through the development of a Resilience Framework for Action. CityRAP is used in small to intermediate-sized cities in sub-Saharan Africa.

South Africa

The integration of resilience in building codes, in particular to address storm-water risks, is increasingly a focus of urban planning and building regulations. This entails both the implementation of sustainable storm-water engineering systems, and knowledge and policy tools to reduce risks and impacts through behavioural changes, public awareness campaigns and training. These approaches are increasingly being applied in development planning in South Africa, and their inclusion has recently become mandatory for new buildings in the city of Cape Town and in Durban, to mitigate the potential impacts of new developments with impermeable surfaces on surface water flows (The World Bank, 2017).

Ghana

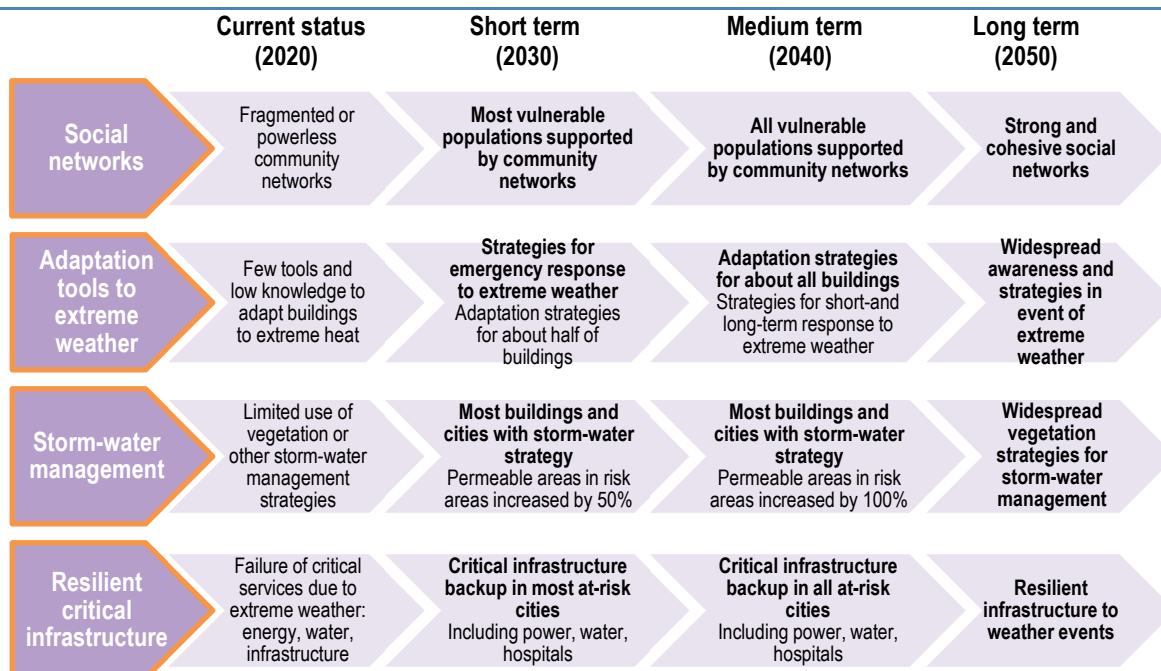
Accra, the capital of Ghana, is a city of rapid urban expansion. It grew from 1.3 million inhabitants in 1991 to 4.4 million in 2014 and has expanded from 133 square kilometres (km²) to 863 km² over the same period. This rapid development has created complex challenges for the local government regarding urban planning, service provision and resilience actions. Accra is especially vulnerable to floods and earthquakes, as well as fires, sanitation issues, and infrastructure and building collapse. In recent years, local stakeholders have made significant efforts towards improving the city's resilience.

In this perspective, Accra's resilience strategy, the first of its kind in the country, aims for a smart, sustainable and resilient city. The strategy encompasses three main pillars: 1) Integrated infrastructure planning and service provision; 2) optimising new and existing resources with accountability and transparency; and 3) embracing informality's contributions for resilience building. The strategy also considers specific initiatives in each sector to address the city's identified challenges. The implementation stage started in 2019 (Accra Metropolitan Assembly, 2019).

Technology for resilience

The life-cycle energy and emissions for buildings are influenced by the resilience of the building and its components. Specific targets and timelines for resilience are outlined in Figure 30:

Figure 30 • Technology timelines for resilience in Africa



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

Details on the technology targets for resilience are outlined below.

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

- **[data gap] Social networks:** The promotion of cohesive and engaged communities is one of the drivers of urban resilience with the most robust empirical evidence (Therrien et al., 2018). As a result, many grassroots groups and local government authorities are actively promoting urban resilience by building tightly knit community networks, in particular in informal neighbourhoods. When community residents and neighbours form close relationships, they can better understand and respond to the changing needs of others, in particular the most vulnerable, the elderly and children.
- **[data gap] Adaptation tools to extreme weather:** African cities are vulnerable to a variety of extreme weather risks including intense rainfall, and to changes in the frequency and/or severity of extreme events, such as fires, floods, heatwaves and storm surges. Informal-settlement dwellers often live in high-risk urban locations, often lacking basic infrastructure and services to withstand the extreme weather. Heatwaves are estimated to cause 12 000 deaths annually across the world. The World Health Organization forecasts that by

2030 there will be almost 92 000 deaths per year from heatwaves, with that figure expected to rise in 2050 to 255 000 deaths annually unless national and local governments adapt to heat-related risks (WHO, 2014). Population growth in areas with high average temperatures means that by 2040 over 1 billion people in sub-Saharan Africa will be living in areas that need space cooling (potentially reaching 1.2 billion people if the world continues on its current trajectory of warming) (IEA, 2019a). As a result, cooling will be a predominant parameter in Africa's future buildings sector energy demand (IEA, 2019a). Building envelope efficiency and thermal comfort systems can reduce the impact of extreme climate conditions. This includes achieving the targets for envelope thermal resistance, air sealing, heating, cooling and ventilation in other activities. Measures also include providing cool spaces for people to shelter from extreme heat.

- **[data gap] Storm-water management:** In the wake of Hurricane Sandy and the increase in frequency and severity of climate impacts in urban areas, the paradigm of [Design with Nature](#) first conceptualised by Ian McHarg has generated new thinking and momentum. Impervious surfaces in urban areas such as asphalt and concrete constrain natural drainage, exacerbating peak flows and flood risks. In many coastal cities, wetlands are turned into hard surfaces and mangroves are cleared to make space for construction, removing important buffers against floods and storms. By safeguarding natural buffers to enhance ecosystems' protective functions and designing parks and green features (e.g. [bioswales](#)), urban planning and landscape design interventions can optimise rain-capture potential and enhance protection from extreme rains (Aponte, 2019). In broader terms, "green infrastructure" (e.g. parks, greening of pedestrian corridors, permeable vegetated surfaces, street trees, community gardens and urban wetlands) is an important tool to enhance resilience through an ecosystem services approach (United Nations Task Team on Habitat III, 2015). Significant process has also been made recently in the design of more sustainable engineering mechanisms to deal with urban storm-water problems.
- **[data gap] Resilient critical infrastructure:** Critical infrastructure systems provide essential services that underpin and sustain vital societal functions such as energy, water, health, food and public safety. Because of cascading effects of potential disasters, critical infrastructure resilience is inherently a multi-organisational process (UN ISDR and ARISE, 2018). Every city should have a resilient critical infrastructure strategy, for example focusing on resilient power systems to ensure that critical public and private facilities can keep operating, the communication systems running and emergency services remain functional in the event of a power disruption. Resilient power technologies such as solar plus battery storage to protect critical facilities from power outages can enable this function (NREL, 2019). Embedded microgrids, which include renewable energy distributed generation combined with energy storage, load management and smart systems, can disconnect from the main grid through "adaptive islanding" in the event of major disruptions. These microgrid solutions are emerging as a key element of urban energy systems resilience (Ostefeld, Whitemeyer and Von Meyer, 2018). According to a 2019 World Bank market report, there are currently around 1 500 minigrids in Africa and 4 000 additional systems are planned, over half of them in Senegal and Nigeria (ESMAP, 2019). Many of these microgrids can be adapted with additional resilience features.

Box 23 • Regional examples of action on technology for resilience

A framework for strengthening climate resilience in African cities

The [African Centre for Cities](#), an interdisciplinary research and teaching programme focused on identifying systemic responses to the challenges of urbanisation in Africa, and the [Climate and Development Knowledge Network](#), a network working to enhance the quality of life and resilience of the poorest and most vulnerable to climate change in Africa, have jointly developed a framework to strengthen climate resilience in African cities. Their goal is to support and facilitate development in African cities that addresses the specific challenges associated with informality and inequality, while integrating climate change and long-term sustainability considerations. The proposed [framework](#) is based on a review of relevant literature, stakeholder interviews and site visits in Accra, Addis Ababa and Kampala, and two expert workshops hosted in Cape Town. It distils a set of key principles as a guide for undertaking climate-compatible development in African cities. The framework factors in climate dynamics alongside the socio-economic, spatial and political dimensions of development (Taylor and Camaren, 2014).

Senegal

As the economic heart of Senegal, Dakar experiences high growth rates mainly reflected in the demand for electricity. The city is the main centre of consumption in the country, with a demand close to 1.3 TWh in 2013 (roughly 57% of the national demand) and an annual growth rate of 4.4%. The capital is expected to double its consumption from 2013 to 2030.

However, Dakar suffers the negative economic impact of an intermittent and limited electricity supply. On average, it experiences close to 12 power outages per month and requires an additional 50 MW of installed capacity to meet the current demand. These conditions result in a loss of 1% of the economic activity in urban centres every year.

Since the electricity sector is managed by the central government, the actions that can be taken by the city are limited. However, Dakar has focused on improving the resilience of the electrical system and of the entire city through specific actions defined in its resilience strategy published in 2016.

The local government has promoted the adoption of energy-efficient technologies as a way of enhancing the electrical system performance in the long term and therefore the city's resilience. The promotion of standards on electrical system installations, the adoption of energy-saving opportunities, wide adoption of LEDs by phasing out incandescent light bulbs, and wide adoption of efficient air conditioning are some of the actions considered by the [Dakar resilience strategy](#) (City of Dakar, 2016).

Finance for resilience

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

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

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

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

Capacity building for resilience

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

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

Table 21 • Capacity building for resilience in Africa

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

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

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

- **Training within government:** Provide training to central and local government about assessing climate risks, developing vulnerability maps, collaborating across multi-stakeholders regarding the development of integrated policies aiming at enhancing resilience in the built environment. Provide training regarding how to communicate the risks and the benefits associated with improved resilience. This will require data collection and analysis to enable the creation of databases, resource platforms and information campaigns.
- **Training of professionals:** Provide training programmes for service and product providers of buildings and construction (architects, engineers, contractors, etc.) regarding how to design buildings with increased resilience to climate risks. Provide training on how to comply with policies such as resilience requirements in building codes or urban plans. Develop educational programmes including primary, secondary, vocational, university and adult education, to enable increased knowledge of resilience.

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


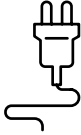


Further details regarding capacity-building activities are provided in the section “Roadmap support: Enablers”.

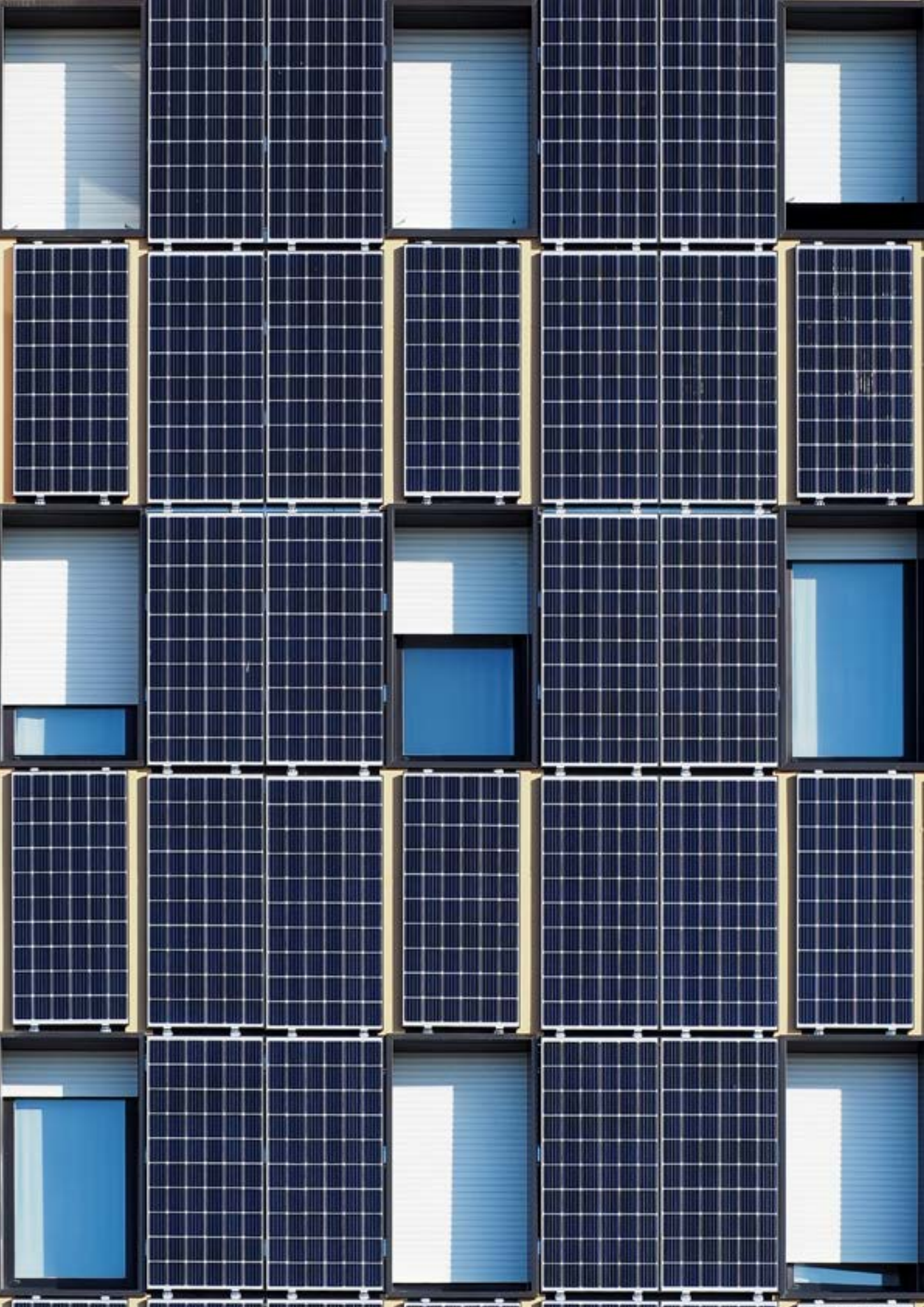
Multiple benefits of resilience

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

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

Table 22 • Multiple benefits of resilience in Africa

Environment	
	<ul style="list-style-type: none"> • Resource efficiency – resilient buildings have a longer useful life.
Energy	
	<ul style="list-style-type: none"> • Energy savings – buildings designed to withstand extreme heat and cold are more energy-efficient; buildings resilient to natural disasters have a longer useful life.
Economy	
	<ul style="list-style-type: none"> • Productivity – resilience reduces operational disruption to cities and services. • Asset value – resilient buildings have lower risk of damage due to extreme weather events or natural disasters, improving property values and reducing insurance costs.
Society	
	<ul style="list-style-type: none"> • Poverty alleviation – resilient buildings can better withstand extreme weather events or natural disasters, reducing loss of homes and infrastructure. • Health and well-being – resilient, durable buildings can withstand extreme weather events or natural disasters, delivering improved physical and mental health and well-being. • Safety and security – resilient buildings can withstand extreme weather, leading to increased safety and security of their occupants.



Activity 8: Clean energy

Buildings account for 61% of final energy consumption in Africa, and good management of their energy supply and demand will be key to enabling a transition to clean energy. Shifting to clean energy sources allows for reduced fossil fuel dependency, greater energy autonomy, reduced environmental impacts, reduced GHG emissions and climate change mitigation, as well as provides employment opportunities. ESCOs can help overcome high upfront costs for renewable and energy efficiency companies, making their diffusion broader, while demand response and energy storage can play important roles in enabling a greater penetration of variable renewables in the energy mix.

Box 24 • Clean energy in Africa: Trends and challenges

Africa is set to emerge as a key driver of global energy demand growth, one that is home to abundant reserves of fossil fuels, solar power and minerals that will be vital for clean energy transitions worldwide. Africa's growing urban populations will require ever more energy to power industrial production, air conditioning and expanding use of transport.

Africa has ample renewable energy resources, and its renewable energy power potential is substantially larger than the current and projected power consumption of the continent. Growth has been constrained, so far, by limited access to financing, underdeveloped grids and infrastructure, unstable off-taker financial arrangements, and, in many countries, an uncertain policy environment (IEA, 2018b). Despite this, recent advances in renewable energy technologies and accompanying cost reductions mean that the large-scale deployment of renewable energy now offers Africa a cost-effective path to sustainable and equitable growth. In many parts of Africa, decentralised renewable energy technologies offer an economical solution for electrification in remote areas as well as for grid extension.

For example, while Africa has the richest solar resources on the planet, it has installed only 5 gigawatts (GW) of solar PV, accounting for less than 1% of global capacity. With the right policies, solar could become one of the continent's top energy sources. Natural gas, meanwhile, is likely to correspond well with Africa's industrial growth drive and need for reliable electricity supply. Today, the share of gas in sub-Saharan Africa's energy mix is among the lowest in the world. However, that could be about to change, especially considering the supplies the continent has at its disposal: it is home to more than 40% of global gas.

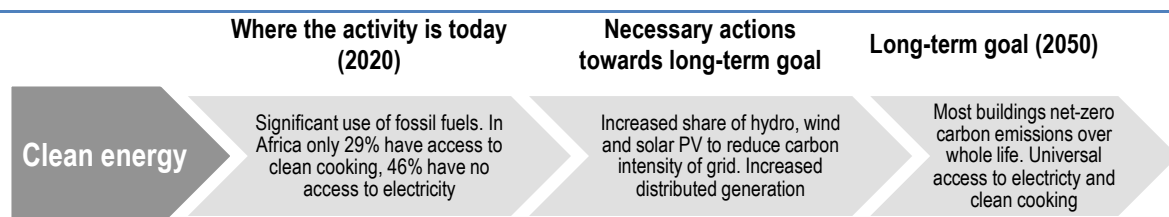
Effective energy policy choices are essential to deliver Africa's inclusive growth ambitions (such as those contained in the region's Agenda 2063 strategic framework), and to help meet other major sustainable energy and development goals.

Delivering access to clean energy in an integrated way would also support economic growth and overall development. Research suggests that access could bring new avenues of productive employment to remote populations, particularly for women. In addition to freeing up time by speeding up domestic chores and giving women more time to engage in paid jobs, access to electricity can have a particular impact on female-owned businesses, helping them to transition from extreme poverty to near middle-class status, as shown recently in Ghana (Power Africa, 2019).

The lack of access to clean cooking remains very acute in sub-Saharan Africa with small improvement rates (15% in 2015 to 17% in 2018). Since 2015, only 25 million people have gained access to clean cooking in the region, meaning that the number of people without access increased to over 900 million in 2018 as population growth outpaced provision efforts. Clean cooking must reach 100% by 2030 in order to meet SDG 7.1. Sub-Saharan Africa is the only region where the number of those without access continues to rise significantly, highlighting the urgent need for action.

Key actions for clean energy

Figure 31 • Key actions for clean energy in Africa



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

- **Eliminate on-site traditional burning equipment.** Replace on-site traditional burning systems with equipment that uses clean energy, including that for cooking.
- **Accelerate universal access to clean cooking and to electricity.** Continue progress on electrification, still lacking in remote areas and overburdened cities. Closing this gap will require private-sector financing, robust policy-planning frameworks, distributed renewables, and extension and strengthening of electricity grids. In order to reach access to clean cooking by 2030 for the over 900 million still lacking, solutions will include LPG in cities and improved biomass or solar thermal in rural areas, with electric devices emerging as possible cost-effective solutions.
- **Integration of on-site renewable energy.** Include PV, building-integrated PV, solar thermal, waste-to-energy, micro-wind, and energy storage projects in the planning and design of buildings and neighbourhoods. These technologies reduce reliance of buildings on centralised power plants that are not often based on clean energy. Lowering regulatory and financial barriers is key to widespread adoption of these technologies by building developers and households.
- **Update regulatory framework and incorporate renewables in utility planning.** Different African countries have varying degrees of liberalisation and decentralisation of their electric power industries. For those with centrally planned structures, a more direct planning and resource allocation would be necessary for introducing renewable energy. For those with more liberalised markets, updates in the regulatory framework to incentivise utility-scale and distributed renewable energy developers would be necessary. Many African countries have traditional vertically integrated and centrally planned electric power industries. This allows a more direct planning and resource allocation for renewable energy in the grid. Some regulatory updates will be necessary for allowing decentralised energy production in larger buildings and neighbourhoods.
- **Provide adequate financial incentives and reflective pricing of energy.** Value-added tax exemptions and near-zero or zero-interest loan rates help spur investments towards clean energy. Measures such as feed-in tariffs help spur utility-scale investments, while establishment of net-metering or peer-to-peer energy trading help spur distributed renewable energy investments.
- **Green power procurement.** In cases where local distributed generation is not sufficient, buildings and neighbourhoods can buy clean energy from the grid through power purchase agreements (PPAs). Depending on the country's power sector structure, some regulatory changes might be needed to enable the conditions to allow such procurement to take place.
- **Zero-carbon policies.** Create and implement zero-carbon policies in order to unify the different aspects of the buildings and construction life cycle towards a common goal. This allows the different stakeholders to balance out the efforts towards material and energy efficiency, on-site clean energy production, and carbon capture in an optimal way.

Stakeholders for clean energy

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

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

Table 23 • Stakeholder mapping for clean energy in Africa

National government	Subnational government	Utility companies	Property and project developers	Financial institutions	Architects and engineers	Manufacturers, retailers and suppliers*	Labourers and installers	Building owners and occupants	Civil society**

* of appliances and materials

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

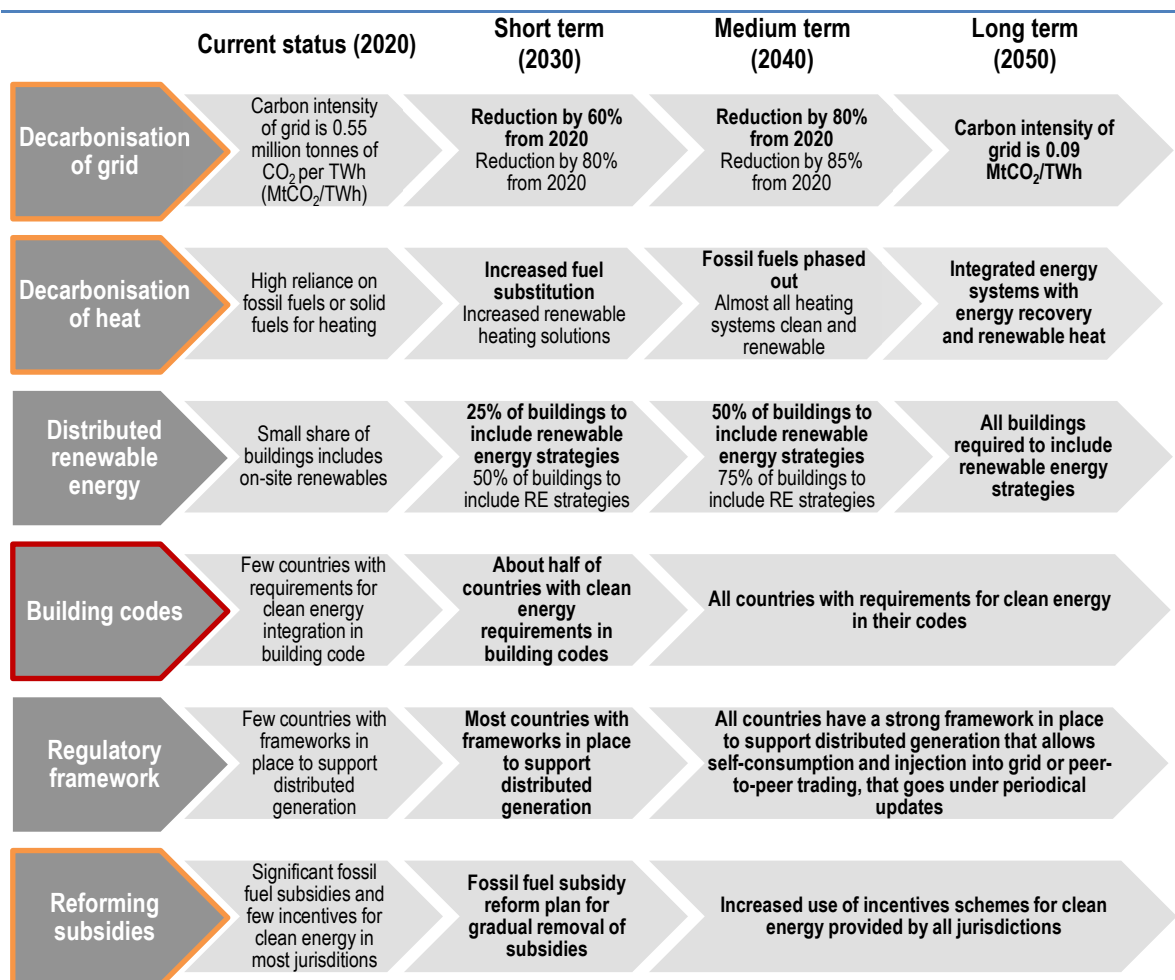
How to read: The darker the colour, the higher the impact that stakeholder group has on the activity and the more essential they are to delivering the roadmap targets.

Policy for clean energy

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

Within the targets for clean energy, the sub-targets and timelines in Figure 32 offer more details:

Figure 32 • Policy timelines for clean energy in Africa



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Notes: RE = renewable energy. The **proposed regional target** is in **bold**. Below that is the proposed accelerated target.

Details on the policy targets for clean energy are outlined below.

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

- **[data gap] Decarbonisation of grid electricity:** North African countries and South Africa are the main regions heavily reliant on coal and gas to supply the power sector. Yet high solar and coastal wind potential is high, providing opportunities to decarbonise the grid. The rest of Africa is already relatively low-carbon, but future growth in the demand for electricity

needs to be taken into account. Expanding hydropower is a viable option, with a total potential of 1 120 TWh and over eight times today's hydropower generation level in Africa (IEA, 2019d). Decarbonising the grid should take into consideration the impacts of increased energy access and decarbonising the end uses (see "Activity 5: Appliances and systems"), which might involve switching to electricity. *Stakeholder feedback: Little information was obtained as to how achievable the target from the SDS is considered by stakeholders.*

- **[data gap] Decarbonisation of heat:** The decarbonisation of heat will be enabled by increased penetration of renewable heat solutions and the elimination of fossil fuels and solid fuels. This switch will be enabled through strong policies and market mechanisms to make cleaner solutions more affordable.
- **Distributed renewable energy:** On-site generation of renewables is one of the possible strategies to achieve net-zero energy or carbon at the building level. Building projects should undertake feasibility studies for the installation of these systems, and take decisions based on a life-cycle financial and environmental basis. 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 the community level. *Stakeholder feedback: There was consensus that renewable energy strategies will be increasingly adopted, given the continent's high solar potential. As large portions of the populations in Africa are yet to be electrified, bottom-up approaches of electrification via off-grid community-scale distributed renewable energy can increase the size of the market and achieve energy access goals at the same time.*
- **[ambition gap] Building codes:** The incorporation of measures such as readiness for demand-side response, obligations for renewable energy systems or provisions for their future installation (e.g. structural integrity requirements) can be stipulated in building codes. These codes should be developed jointly among national authorities, builders and other stakeholders so appropriate technologies are considered and mandatory requirements are practical, enforceable and well designed. *Stakeholder feedback: Current consensus was that "about half" to "most" of countries would incorporate requirements to incorporate renewables in building codes.*
- **Regulatory framework:** Regulation is key to encourage the large-scale integration of clean and renewable resources in buildings and district energy systems. Regulatory frameworks define the conditions to connect and operate distributed resources and district energy infrastructure, besides guaranteeing access to energy markets in order to sell surpluses at efficient prices. These factors allow an easy adoption of on-site generation of renewables. Frameworks covering technical regulations and administrative provisions for multi-dwelling PV installations also help increase uptake in dense urban environments. *Regulation was mentioned as a barrier by several respondents, quoting the conflict with utility providers to increasing self-generation.*
- **[data gap] Reforming subsidies:** The environmental and health costs of fossil fuel usage must be accounted for when comparing the costs of fossil fuels with 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. In sub-Saharan Africa, subsidies for kerosene, generally used for cooking and lighting, costs USD 2 billion per year (Evan, 2017). Subsidy reforms could enable replacements such as solar lighting distribution instead.

Similarly, incentives can be used to promote clean energy. These incentives can be non-financial, such as expedited product approvals and permits, or financial. Non-financial incentives offer appropriate enabling conditions for the development of renewable energy technology, while financial incentives can substantially accelerate its deployment by encouraging private investment. *Stakeholder feedback: There was consensus that incentives would become increasingly available for renewable energy.*

Box 25 • Regional examples of policy action on clean energy

South Africa

In May 2019, South Africa, the most energy-intensive economy in Africa, introduced a carbon tax. The policy makes South Africa one of only a few emerging economies with a legislated price on carbon. In the initial phase, up to December 2022, a tonne of carbon will cost roughly USD 8, but will be lower for many industries, to provide them with a form of short-term transitional assistance. Nevertheless, a 2% annual increase in price is foreseen and industry assistance will be phased out after the pilot phase.

Namibia

The Green Soft Loan launched in 2013 lets Namibians borrow up to 100 000 Namibian dollars (approximately USD 6000) for installing solar thermal or PV with an interest rate of 4.25%, which is less than that charged by the commercial banks.

Cote d'Ivoire

The solar-home-system industry provides small-scale household solar PV and storage systems on a “pay-as-you-go” basis. This system works by providing micro-finance to households who pay off and eventually own their solar systems. To support the development of this market, in 2018 the African Development Bank approved a USD 27.78 million proposal to provide a local currency loan to a solar-power kit provider in Cote d'Ivoire to provide solar home systems to a further 100 000 households on a three-year pay-as-you-go, rent-to-own basis. The government of Cote d'Ivoire has also stated its intention to develop the solar home kits as well as pass national legislation on the thermal efficiency of buildings. It has also stated its intention to offer training in low-energy construction for stakeholders in the construction value chain.

Regional

The Southern African Solar Thermal Training and Demonstration Initiative (SOLTRAIN) is a regional initiative that started in 2009 with the objective to shift to renewable energy using solar thermal or heating systems. In its first two phases (2009-16), it installed 187 small- to large-scale solar heating systems and trained 2 150 people. The project is currently in its third phase with more focus on institutions supporting women.

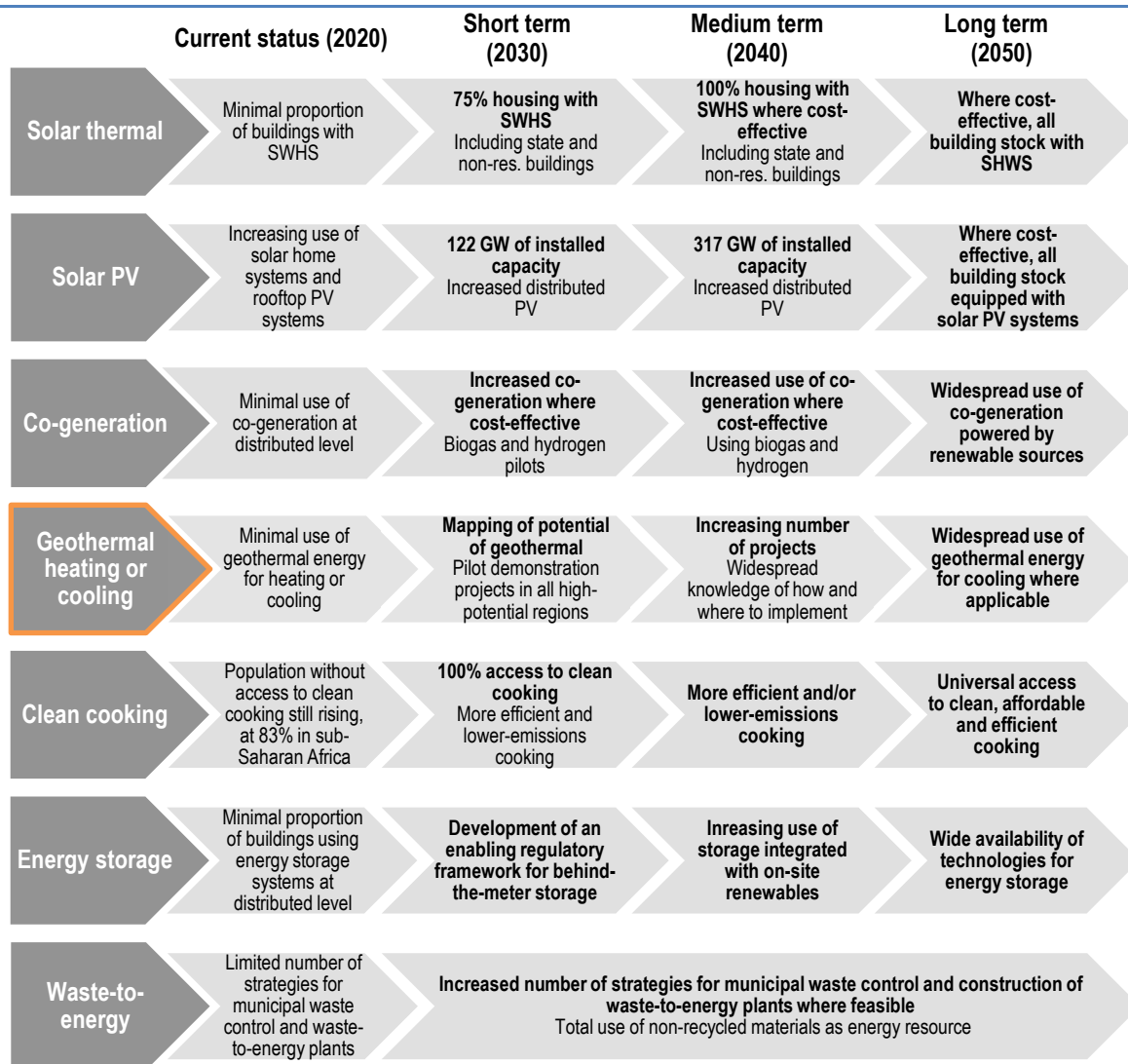
Solar Sister's goal is to make women an integral part of the clean energy value chain in Africa. Solar Sister promotes off-grid lighting through a micro-consignment model applied by collaborating with formal and informal women's organisations. It combines the breakthrough potential of portable solar technology with a women-driven direct sales network to bring light and opportunity to a range of communities without reliable electricity access. Through the micro-consignment model, Solar Sister entrepreneurs get a “business in a bag”, a start-up kit of inventory, training and marketing support to bring clean energy directly to their customer's doorsteps (African Development Bank, 2016).

Technology for clean energy

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

Specific targets and timelines for clean energy are outlined in Figure 33:

Figure 33 • Technology timelines for clean energy in Africa



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Notes: The **proposed regional target** is in **bold**. Below that is the proposed accelerated target. A red border indicates an ambition gap for that target (more details below); an orange border indicates a gap in data or consensus (more details below). Solar PV capacity increase is based on combined total of utility-scale and distributed PV capacity in the SDS (IEA, 2019a).

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

- **Solar thermal:** On-site solar thermal collectors produce hot water in a renewable way and should be encouraged in areas of high solar radiation. A SWHS can replace electric hot water production or the use of fossil fuels at a competitive price. *Stakeholder feedback: There was consensus that solar thermal systems would be very widespread by 2050.*
- **Solar PV:** On-site building-integrated or roof-mounted PV can enable the generation of electricity for self-consumption. Depending on the size of the installed system, buildings may be able to meet their electricity needs partially or completely on an annual basis. Coupling with BESS (battery energy storage systems) can provide off-grid buildings with the flexibility needed 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 DC home solar systems also offer significant potential for increasing access to electricity. The targets outlined above are based on the capacity of solar PV generation in Africa in the IEA SDS (IEA, 2019a). *Stakeholder feedback: Consensus was that “about half” to “most” buildings would adopt rooftop PV by 2050, although the limited cost-effectiveness on buildings with small footprints was cited as a barrier to uptake.*
- **Co-generation:** Co-generation can provide significant gains in terms of energy efficiency and reduction of CO₂ emissions in buildings by recovering waste heat from electricity production and using it for water and space heating. Co-generation can use a variety of fuels, from fossil fuels to biogas, biomass and even hydrogen. Co-generation systems can be expanded to tri-generation (combined cooling, heat and power) to produce chilled water for space cooling. *Stakeholder feedback: There was consensus that the adoption of co-generation would be limited.*
- **[data gap] Geothermal heating or cooling:** Geothermal systems exploit the earth or bodies of water as a heat sink, to provide heating or cooling. They can be used in combination with a heat pump or, where temperatures allow, in a direct circulation loop. Policy support in the form of risk guarantees or investment grants can help mitigate investment risks associated with high upfront costs. *Stakeholder feedback: Little information regarding the potential for geothermal energy in this region was obtained.*
- **[data gap] Clean cooking:** The use of traditional biomass for cooking is responsible for significant air pollution, deforestation and missed development opportunities. There is no single solution, and universal clean cooking can be achieved through a combination of switching to gas and electric cookers, efficient stoves, and modern biomass, taking into account local circumstances and cultural acceptability. For instance, in IEA SDS, this switch can be achieved through reduction of traditional biomass use by 85%, bringing down fine particle (PM 2.5) emissions by 95% by 2040 from 2018 (IEA, 2019a).
- **Energy storage:** With increasing shares of variable and non-pilotable renewable energy in the energy supply, energy storage becomes an important element for balancing supply with demand. 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 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 1) economies of scale; and 2) the smoothing effect from both demand and supply aggregation, which reduces the overall storage capacity needs and the intensity of its use. *Stakeholder feedback:*

In many areas of Africa where energy access is still a challenge, energy storage serves as an important component of off-grid variable renewable energy systems.

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

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

- **Small-scale hydro:** Historically, small-scale hydro was an important energy source for industrial buildings that were located near rivers. Currently, most small-scale hydro is directly fed into the power grid and not used on-site. It is common that these types of projects do not have storage capacity or water reservoirs, in contrast to large dammed hydroelectric plants. *Stakeholder feedback: There is substantial hydropower potential in Africa. On-grid hydropower capacity can triple by 2040 compared with 2018 in the IEA Africa Scenario, which is based on the African Union's Agenda 2063 (IEA, 2019d).*

Box 26 • Regional examples of action on clean energy technology

Morocco

The provinces of Midelt and Tata, among others, have high renewable energy potential due to high solar radiation. Noor is a Moroccan solar project with plans for installation of solar power plants with a total capacity of 2 000 MW. The project has been implemented in four pilot municipalities with energy-efficient measures taken in public lighting systems, refurbishment of classrooms and installation of stoves. For capacity building, training courses on PV installation have been developed for the technicians.

Kenya

Buildings in Kenya with consumption of more than 100 litres of hot water per day are required to install SWHS as part of its Energy (Solar Water Heating [SWH]) Regulations 2012. Incentives include the exemption of solar water heater units from value-added tax, which is coupled with a penalty of potential disconnection of electricity supply for failure to comply. The 2017 estimate of SWH units is only 77 000, but the untapped market potential is 2 million units (EED Advisory Ltd, 2018).

South Africa

The first solar district heating system in South Africa has been installed in the Wits Junction. The installation combines solar thermal collection with co-generation and gas heating technology, and serves 14 student residences of more than 1 000 people from a centralised hot water plant room. This forms part of a larger programme of SOLTRAIN, which has built 326 solar thermal systems, saving about 2 000 megawatt-hours per year and avoiding 638 tonnes of CO₂ (SOLTRAIN, 2019).

Mozambique – solar home system pay as you go

Since 2016 SolarWorks! Mozambique has set up operations in the country to offer off-grid solar home solutions, on a pay-as-you-go basis with mobile money (mobile phone based cash transfer and payment systems), providing a complete service including sale, installation, maintenance and customer care. Products range from a lantern with phone charging capabilities to a multi-light solar home system capable of powering small AC appliances, such as televisions and laptops (ALER – Associação Lusófona de Energias Renováveis, 2017).

Finance for clean energy

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

- **Green power procurement:** Depending on the regulatory framework, large electricity consumers can go to the competitive market to procure electricity directly from renewable energy projects or green-electricity retailers. In this way, buildings can support renewable utility- or distributed-scale projects through the creation of demand. Green power procurement is a common practice in some cities around the world, where municipalities decide to meet the electricity demand of public buildings through PPAs linked to renewable projects.
- **Urban development funds:** Dedicated funding for urban development projects, which can be directed towards renewable energy projects.
- **Infrastructure funds:** Dedicated funding for infrastructure projects, which can be directed towards sustainable renewable infrastructure projects.
- **Dedicated credit lines:** Funding delivered through banks for a specific purpose, which can prioritise sustainable buildings, construction or development projects. Dedicated credit lines to national or local governments can also be used to establish a revolving loan fund, which collects repaid loans from renewable energy projects and reinvests them in additional energy efficiency or renewable energy projects.
- **Risk-sharing loan/loan guarantee:** Large organisations, such as a government, international bank or aid organisation, covering the risk of payment default to allow banks to fund a project with lower costs and better loan terms.
- **Green bonds:** Bonds that can be used to bundle funding associated with sustainable projects, including renewable energy projects.
- **Preferential tax:** Direct funding from the government to reduce or eliminate the tax for sustainable products and services, including renewable energy projects.
- **Grants and rebates:** Direct funding to overcome upfront cost barriers, provided by a government, organisation or programme either through a competitive process (grants) or during or after the purchase of a sustainable product or service (rebates).
- **Energy performance/energy service contracts:** Contracts for services or delivered savings, typically are delivered by an ESCO, can include a range of energy efficiency or renewable energy services and products.
- **Procurement purchase and lease:** The purchase or lease of sustainable products and services. Leasing enables the use of energy-efficient products or renewable energy technologies on a rental basis to overcome high upfront capital expenditure.
- **On-bill/tax repayment:** An approach where any recurring bill, such as utility bills, insurance bills or home improvement store bills, can collect small amounts of money over a long period of time to pay for energy efficiency purchases in smaller payments. An offshoot of on-bill finance, tax repayment uses recurring tax payments as a means for the tax authority to collect money over time. The most common of these is PACE finance, which is able to use low-interest-loan repayments on the property tax bill until the purchase is fully paid.
- **Community finance and crowdfunding:** Collective funding from a large number of people connected either locally or through a call for funding.

- **Energy prices:** Cost-reflective pricing and subsidies are powerful influencers of how people consume energy. Pricing strategies should be aligned with decarbonisation goals. Pricing based on time of use and location are other mechanisms by which pricing can influence consumption for a more robust integration of renewable energy.

Capacity building for clean energy

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

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

Table 24 • Capacity building for clean energy in Africa

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

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

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

- **Training within government:** Build capacity and awareness in all levels of government on the benefits of clean energy production to the energy system, as well as broader benefits to infrastructure, public health and well-being, and the environment. Provide training on the integration of clean energy in all relevant aspects of policy planning, design and implementation, including in integrated resource planning, investment decisions, and urban planning and buildings sector policies among others. Strengthen capacity in co-ordination between relevant government and non-government organisations to enable improved policy coherence.
- **Training of financiers and developers:** Provide training to financiers and developers in identifying, assessing and financing clean energy projects, both at utility scale and distributed generation. Also, build capacity in creating and nurturing stakeholder networks among policy makers, developers and financiers to build more project pipelines.

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

Multiple benefits of clean energy

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

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

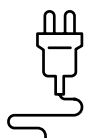
Table 25 • Multiple benefits of clean energy in Africa

Environment



- **Emissions reductions** – clean energy reduces GHG emissions.
 - **Air quality** – many forms of clean energy produce no air pollution, improving air quality.
-

Energy



- **Energy security** – local clean energy solutions improve energy security by reducing reliance on fuel imports.
 - **Energy prices** – cost-competitive clean energy can reduce energy prices as generation profiles often have a strong overlap with peak demand profiles.
-

Economy



- **Economic performance** – clean energy delivers energy productivity improvements.
 - **Employment** – clean energy creates local jobs during the manufacturing, installation, and O&M of renewable energy systems.
-

Society



- **Poverty alleviation** – increasing access to reliable electricity and to clean forms of cooking can bring significant economic opportunity benefits to households.
 - **Health and well-being** – reducing indoor air pollution caused by the use of solid fuels, and by reducing time spent on energy collection or cooking activities increases both health and well-being.
-



Roadmap support: Enablers

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

Box 27 • Enabling activities in Africa: Trends and challenges

Awareness and prioritisation of sustainable buildings and construction are low in Africa. More efforts are needed to communicate the benefits of energy efficiency in buildings to make it a higher priority for all enabling activities including training, data, institutional co-ordination, financing and multi-stakeholder engagement.

Strong political will is needed to prioritise the buildings sector and overcome barriers to establishing baseline data and appropriate targets for high performance. Capacity building and tools for data analysis and processing are critical to make collected data usable and useful. Green Building Councils (GBCs) have played an important role in organising stakeholders in Kenya and South Africa to advocate for change and raise the needed political will, and this model is taking off with many more national GBCs formalising programmes of work across Africa.

Low awareness, prioritisation and political will also hamper the implementation of building codes, which are critical for reducing sector demand. Demonstration projects are critical to convey the range of issues, the scale of the problem, and potential solutions and actions that can be taken. More training is needed for practitioners, and incorporating green buildings in core university curricula is seen as a more effective agent for change.

Adding to these challenges, central banks and national regulations often block access to tools needed for financing such as reduced interest rates or access to capital. Some finance approaches that have been used in the region are not recognised as climate finance, despite their use for climate-related activities such as community finance for resilience among the urban poor. Green bonds have begun to be issued in various countries across the region – such as in Kenya and Namibia – but outside of South Africa, there is a trend of low understanding of how to access this resource.

Capacity building

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

Key actions for capacity building

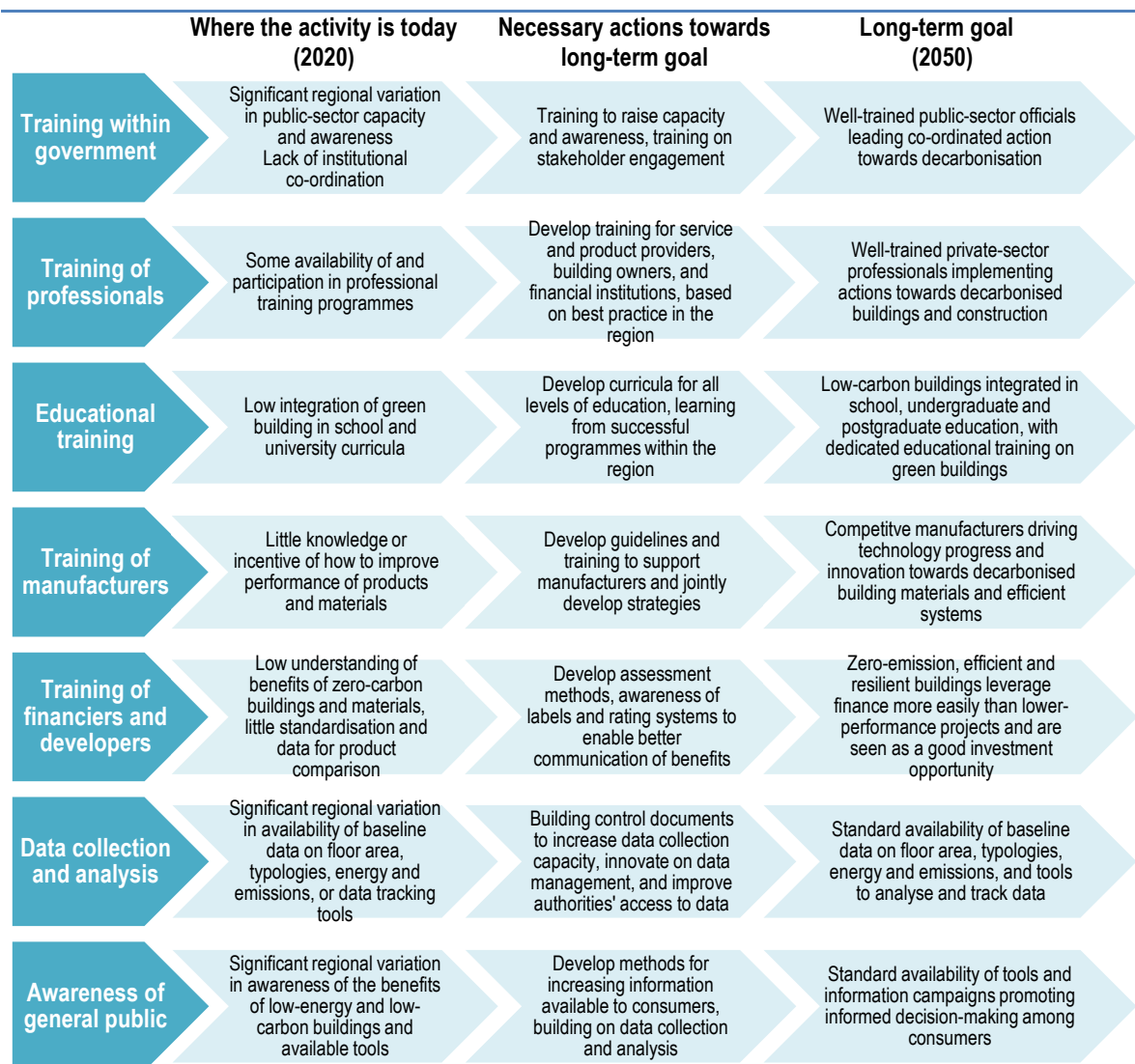
Figure 34 • Key actions for capacity building in Africa

Key actions for capacity building in Africa include:

- **Awareness.** Increase understanding of the benefits of sustainable buildings and construction to make it a higher priority for decision-makers, and increase understanding of financing.
- **Data collection and analysis.** Collect and analyse baseline data for the sector as a whole and/or for high-priority building typologies, including data on the value of sustainable buildings investments, and create or modify tools to process and analyse that data to determine appropriate targets for good performance.
- **Institutional co-ordination.** Strengthen co-ordination among stakeholders to push for accelerated government progress on building codes and other critical policies.
- **Educational training.** Incorporate green buildings and construction in core university curricula across disciplines to make sustainability a normal and expected part of the approach to the sector, especially among youth.

Specific capacity-building targets include:

Figure 35 • Timelines for capacity building in Africa



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Target details for capacity building include:

- Data collection and analysis:** Baseline data on building floor area, typologies, energy consumption and emissions – along with robust tools to contextualise and analyse the data – are a critical first step to understanding the starting point for reaching zero-emission buildings. *Stakeholder feedback: There was consensus that the low prevalence of data collection and analysis is a critical barrier to implementation of many of the policies and actions necessary in the buildings and construction sector.*
- Institutional co-ordination:** Shared goals and co-ordination among relevant government institutions horizontally (i.e. across the national government) and vertically (i.e. between national and subnational governments) and with non-governmental organisations can enable improved policy coherence. For example, national policy can create an enabling environment for local governments to accelerate action towards green buildings, and local policy is required

for strong implementation. *Stakeholder feedback: There was strong consensus that increased political will is required for successful institutional co-ordination.*

- **Training within government:** Increased technical, financial and human resources in the public sector can improve the implementation and enforcement of policies. Creating awareness is also crucial within government institutions on the benefits of green buildings and construction such as economic impacts, public health and well-being, and benefits to the energy sector and the environment. *Stakeholder feedback: There was consensus that there is low public-sector capacity and awareness of the many benefits of sustainable buildings and construction.*
- **Training of professionals:** Training programmes for service and product providers for buildings and construction (architects, developers, contractors, vendors, etc.), building owners, and professionals in financial institutions increase awareness of green building and construction policies, programmes, incentives, and benefits of sustainable buildings and construction. This increases professionals' ability and willingness to implement these programmes.
- **Educational training:** Educational programmes including primary, secondary, vocational, university and adult education enable increased knowledge of green buildings. Certification or accreditation for professionals in the buildings sector can motivate more people to undertake educational training programmes, and increase awareness of who is trained to support green buildings and construction. *Stakeholder feedback: There was consensus that integrating green buildings into core curricula can be a strong agent for change.*
- **Awareness:** Information tools increase awareness, improve decision-making and promote more sustainable choices among consumers. 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. *Stakeholder feedback: There was consensus that there is low awareness of the benefits and general information on sustainable buildings and construction.*

These elements of capacity building have differing relevance across the eight activity areas. A general indication of the relevance of each is mapped in Table 26.

Table 26 • Capacity building across activities

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

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

Box 28 • Regional examples of action on capacity building

South Africa

The [Kuyasa project](#) installed solar water heaters, ceiling insulation and compact fluorescent lamps in over 2 000 homes, leading to annual savings of 7.4 million kilowatt-hours and 6 437 tonnes of CO₂ emissions – or 34% in kilowatt-hours and 33% in tonnes of CO₂ compared with the pre-project baseline. Project partners actively engaged residents in retrofit implementation, allowing the community to benefit from technical training and capacity building.

Kenya

In Kenya, curriculum change has been more successful among universities than with practitioners. While there has been less uptake of green buildings curricula for architects, the idea was well received at universities, with eight of them subscribing to resources developed by UN Habitat for developing countries, including the [Sustainable Building Design for Tropical Climates](#).

SOLTRAIN, Mozambique

In 2016, UN-Habitat and the Municipal Council of Beira opened a Renewable Energy Multifunctional Community Centre in the city of Beira. The centre is a place of new experimentations, production and use of forms of renewable energy to support local economic development and urban resilience. The project aims to provide the Munhava slum's inhabitants with clean energy, better sanitation and clean water and at the same time to provide opportunities to young people and women to learn, exchange experiences and create local initiatives linked to the development of their communities, strengthening community organisation (ALER – Associação Lusófona de Energias Renováveis, 2017).

The Building Efficiency Accelerator

The [Building Efficiency Accelerator \(BEA\)](#) is a global public-private collaboration, run by the World Resources Institute, in partnership with the United Nations Sustainable Energy for all Initiative. The aim of the project is to utilise international knowledge in order to implement energy efficiency policies and programmes on the local level. The accelerator acts as network to connect cities with experts as well as private-sector partners. [Through the BEA](#), 25 cities globally have made 47 commitments to energy efficiency in buildings.

Nairobi, Kenya, joined the BEA in 2017. Through the accelerator, Nairobi has begun drafting green building guidelines and is establishing a pilot programme throughout the city on selected building types.

Through the BEA, Nairobi will have access to experts who can provide location-/climate-specific guidance on policy measures and implementation, which considers existing initiatives, and access to tools to track and document progress, as well as resources on building codes, financing opportunities and incentive programmes.

Finance

IFC estimates that global investments in green buildings in 2017 accounted for about 8% of the resources spent on building construction and renovation – USD 423 billion of a USD 5 trillion market (IFC, 2019). Looking ahead with a focus on emerging market cities, there is a cumulative climate investment opportunity of USD 29.4 trillion to 2030, of which 84% – USD 24.7 trillion – is in green buildings. Of this, USD 768 billion is in sub-Saharan Africa, mostly in the residential sector (IFC, 2019).

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

Key actions for finance

Figure 36 • Key actions for finance

Key actions for finance in Africa include:

- **Institutional co-ordination.** Engage development banks and national governments to remove barriers and unlock access to capital, then work with local banks to help them understand how sustainable buildings and construction can provide a return on investment.
- **Regional best practice sharing.** Share case studies across the region about successes and lessons learned to accelerate the growth of knowledge among buildings practitioners.
- **Build political will.** Enable the prioritisation of the buildings and construction sector to access financing in line with what has been made available for other sectors that have been prioritised, such as affordable housing and slum rehabilitation.
- **Establish new business models:** Facilitate and share the risks and rewards of investing in energy efficiency and zero-carbon buildings by adopting and adapting new business models that allow for private businesses and public institutions to benefit from investment in energy efficiency.

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

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

- **On-bill/tax repayment:** An approach where any recurring bill, such as utility bills, insurance bills or home improvement store bills, can collect small amounts of money over a long period of time to pay for energy efficiency purchases in smaller payments. An offshoot of on-bill finance, tax repayment is a mechanism that uses recurring tax payments as a means for the tax authority to collect money over time. The most common of these is PACE, which is able to use low-interest-loan repayments on the property tax bill until the purchase is paid in full.
- **Community finance and crowdfunding:** Collective funding from a large number of people connected either locally or through a call for funding.

Box 29 • Regional examples of action on finance

South Africa

Johannesburg [issued South Africa's first green bond](#) (COJGO1) in 2014. This 1.46 billion rand (ZAR) (USD 140 million) green bond will mature in 2024 and finance green initiatives on areas such as biogas and solar water heaters. As a fixed-income, liquid financial instrument, the green bond offers an attractive option for investors looking to finance energy efficiency projects.

The sound financial standing of Johannesburg has been key to attracting investors. The city issued its first municipal bond in 2004 and since then, has been a consistent and responsible issuer in the bond market with seven municipal bonds totalling ZAR 8.5 billion (USD 815 million). Johannesburg also received a positive investment rating from major ratings agencies.

South Africa – PSEE, national energy efficiency initiative

The [Private Sector Energy Efficiency \(PSEE\)](#) programme was a two-year initiative to help South African companies benefit from energy efficiency measures. PSEE was a collaboration between the Carbon Trust and the South African National Business Initiative, with financial support of GBP 8.6 million from the UK Government's Department for International Development.

The programme included technical advice such as training and recruiting, development of energy management tools and workshops on energy-efficient technologies (i.e. motors, drivers, heating, ventilation, and air conditioning). Support measures varied depending on the company size.

Over the course of the two-year project, involved businesses saved approximately a combined 3 000 gigawatt-hours (GWh) of energy and 2.2 million tonnes of CO₂. The PSEE workshops attracted 2 000 participants, exceeding overall project expectations. PSEE leveraged USD 4.7 million of capital expenditure, and the implemented technologies had an average payback of 1.4 years.

More information: www.carbontrust.com/our-projects/psee-national-energy-efficiency-initiative.

Kenya

In Kenya, while investment funds are often available, the conditions for access often create hurdles. For instance, there are conflicts between central bank interest rates and credit lines. Some projects have been successful with special low rates of 3-4%, but usually the national bank will not allow mortgage rates less than 10%.

West African States – ECOFRIDGES

The [ECOFRIDGES project](#) aims to provide energy efficiency and climate-friendly cooling products to the countries of the Economic Community of West African States (ECOWAS). The goal of the project is to support the distribution of 50 000 cooling products and develop plans for appliance disposal, as well as run awareness-raising campaigns (such as radio ads, public events and a project website). Additionally, the project will include a finance mechanism (potentially some form of on-bill financing).

The [overall estimated project savings](#) are a reduction of 1 933 kilotonnes of CO₂ annually, 4 288 GWh of electricity savings and USD 472 million in energy bill savings.

The project is a collaboration between the UN's United for Efficiency initiative, the African Development Bank, the governments of Senegal and Ghana, the ECOWAS Centre for Renewable Energy and Energy Efficiency, and the Basel Agency for Sustainable Energy. The project receives funding from K-CEP.

Uganda Green Schools NAMA

The “[green school](#)” nationally appropriate mitigation action ([NAMA](#)) is focused on improving the cook-stove technologies being used in primary and secondary schools in Uganda, where access to clean fuels remains low compared with the rest of the continent. As part of the NAMA, there was a focus on installing improved institutional cook stoves following a business model that used the savings in daily fuelwood expenditure to support the installation and maintenance. The programme made use of a revolving loan fund that the schools and private ESCOs could access and then repay through energy cost-savings alongside funding from the Department of Education. Revolving loan funds are often used where high-risk financing or microfinancing is sought because they use the repayment of loans as a mechanism to replenish the fund and to further finance new loans. Further, in the case of Uganda, some enterprises sold the subsequent carbon credits that would help schools with annual maintenance and help promote continued good practice.

Green bonds in Namibia

The Bank Windhoek, a Namibian-based commercial bank that became the first bank to issue a green bond in the Southern African region in 2018, is listed on the Namibian Stock Exchange. The bond is available for financing renewable and energy efficiency projects that align with green bond principles. The bank is working with the [Agence Française de Développement](#) (AFD) to implement projects through the [Sustainable Utilization of Natural Resource and Energy Finance](#) programme across Namibia.

Green credit lines in Mauritius

The AFD and the Mauritius Commercial Bank and State Bank Mauritius have partnered under the [SUNREF Indian Ocean](#) programme to support public and private banks to invest in low-carbon and energy-efficient technologies and renewable energy. The SUNREF Indian Ocean is a credit line of EUR 60 million that is used to support projects looking to invest in energy efficiency and renewable energy in accordance with AFD standards for lending. The maximum amount on offer for a loan is EUR 7 million, along with an 8% incentive grant payable on successful completion. For energy efficiency, the criteria are an energy savings ratio of at least 20% and a payback in two to eight years from savings, of which at least 50% must come from energy, and make use of BATs. Such criteria for performance can be quite onerous to meet, and the potential is likely to be highly focused on certain types of energy-intensive developments.

Stakeholder engagement

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

Stakeholders to be engaged include:

- **National government:** National governments design and implement policies that enable or disable the uptake of sustainable building and construction. National governments act as regulators and can play an important role in facilitating partnerships among other stakeholders.
- **Subnational government:** Subnational governments play a critical role in developing, implementing and enforcing policy. In addition to their regulatory role, cities and states can convene actors across sectors, and can take action as owners of public buildings.
- **Utility companies:** Utilities have significant building data and valuable relationships with owners and tenants that already include payment and financing. In some cases, utilities also have to comply with legislation to reduce their emissions. Utilities can therefore be either a significant barrier or enabler to action on sustainable buildings and construction.
- **Property and project developers:** Developers make decisions about how property will be used, including cost-benefit assessments for different building and construction approaches. These early decisions can have far-reaching impacts into what options are considered in a building or construction project.

- **Financial institutions:** Financiers provide mechanisms to make the necessary upfront investments for sustainable buildings and construction, with repayment often coming from the energy-saving benefits that develop over several years.
- **Architects and engineers:** Professionals who lead on technical project design determine what is possible within the parameters set by developers. Professional and educational training provides these experts with the knowledge they need to incorporate sustainable building and construction design.
- **Manufacturers, retailers and suppliers:** Companies that make equipment and systems determine which products are available on the market and whether building upgrade solutions are sold with a systems view or by piecemeal replacements over time.
- **Labourers and installers:** Construction professionals must interpret project designs and bring them to life, and there are many opportunities for real-life installations to fall short of the sustainability envisioned in the designs on paper. Professional training is critical for labourers and installers to implement sustainable buildings and construction.
- **Building owners and occupants:** Owners and occupants are responsible for paying for any building upgrades and energy bills, and get the benefit of improved energy services.
- **Civil society:** Civil society organisations, such as consumer and environmental advocates, or social service providers can provide capacity and expertise to improve government decision-making. Civil society can represent the perspectives of communities that may otherwise be absent from buildings and construction dialogues.

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

Table 27 • Mapping of stakeholder types across activities

	National government	Subnational government	Utility companies	Property and project developers	Financial institutions	Architects and engineers	Manufacturers and retailers	Labourers and installers	Building owners and occupants	Civil society **
Urban planning	Light Green	Medium Green	Medium Green	Light Green	Light Green	Medium Green	Light Green	Light Green	Light Green	Medium Green
New buildings	Light Green	Medium Green	Light Green	Medium Green	Light Green	Medium Green	Medium Green	Light Green	Light Green	Light Green
Existing buildings	Light Green	Light Green	Light Green	White	Light Green	Light Green	Light Green	Medium Green	Medium Green	Light Green
Building operations	Light Green	Light Green	Light Green	White	White	Light Green	White	Light Green	Medium Green	White
Appliances and systems	Medium Green	White	Light Green	White	White	Light Green	Medium Green	Light Green	Light Green	Light Green
Materials	Light Green	Light Green	White	Light Green	Light Green	Medium Green	Medium Green	White	Medium Green	Medium Green
Resilience	Light Green	Medium Green	Light Green	Light Green	Light Green	Light Green	Light Green	Medium Green	Medium Green	Medium Green
Clean energy	Medium Green	Light Green	Medium Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green

* of appliances and materials

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

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

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

Several approaches can facilitate stakeholder engagement. For instance, a **SWOT (strengths, weaknesses, opportunities and threats) analysis** can be facilitated collaboratively with stakeholders to better understand what will drive successful policy for sustainable buildings and construction and what threats may exist. A **PIE (progress, impact, effort) multi-matrix** (such as the [Assessment Tool for Building Efficiency Policies](#)) can seed stakeholder discussion to prioritise policies for action. Stakeholders can collaboratively use a **responsibility matrix** such as RACI (responsible, accountable, consulted, and informed) to clearly identify which roles are appropriate for each stakeholder throughout policy roadmap development and implementation.

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

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

[Green Building Councils \(GBCs\)](#)

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

Across the Africa GBC network, only South Africa has an established GBC; however, Kenya has an emerging GBC in the Kenya Green Building Society, with Cameroon, Ghana, Mauritius, Namibia, Rwanda and Tanzania having prospective member organisations.

National alliances

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

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

In Africa, national alliances have been successfully established in Morocco through the [Alliance Marocaine du Bâtiment pour le Climat](#) (Moroccan Alliance for Buildings and Climate) and Tunisia through the Alliance Tunisienne Pour les Bâtiments et la Construction (Tunisian Alliance for Buildings and Construction).

Conclusions and outlook

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

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

The African building stock is characterised by a number of emerging urban centres across the region that will soon become mega-cities, which are growing to accommodate very large rural to urban and regional migration patterns. Over the past two decades, the growth in population and a continued increase in wealth has led to increased energy demand, though still with a high reliance on traditional fuels and growing access to clean energy. Increasing building energy performance and technology adoption has been slow but is steadily increasing. Across the region there remain few building codes and performance standards, which are needed alongside a shift in adoption of low-cost, low-energy technologies and designs, and policies that support technological and financial innovation and the adoption of more integrated planning polices and low-carbon materials.

This Africa Roadmap can serve as a tool for countries across the region to adopt constructive steps towards a zero-carbon, efficient and resilient buildings and construction sector when undertaking the 2020-25 NDC revisions, even supporting the monitoring, reporting and verification process for NDCs. The African buildings sector is faced with many challenges in terms of improving construction practices for high-quality buildings, availability and affordability of housing, and a fast-growing demand for energy-using services. This roadmap also supports organisations in their buildings investments strategies by identifying goals and milestones, and offers a basis for detailed national or local roadmaps. Through a shared vision, these documents aim to facilitate co-operation among the entire value chain in the buildings and construction sector as well as among countries within the African region.

This document provides indicative targets and timelines for establishing both a proposed pathway of improvement in the planning, development, operation, servicing and resilience of the building stock in Africa, along with ambitious or “stretch” targets that allow countries and subnational entities to push further faster. It is the expectation that these documents, the themes, checklists, guides, recommendations, stakeholder mapping, examples and key actions, can help guide policy-making and raise awareness to help build political argument for more ambitious buildings and construction policies and market signals. The key actions aim to provide policy and decision makers with achievable steps in their efforts to promote the development of a zero-emission, efficient and resilient building stock in Africa between now and 2050.

Yet there is still much work to do. Although the Africa Roadmap is the product of extensive consultation and expert input, there are activities and action areas that need more data to ensure the proposed targets are set on a solid footing. The need remains to address information gaps and to build the evidence base and support tools for zero-carbon new building construction, as well as to improve integrated urban planning and clean energy systems. There is an information gap on material use and its carbon intensity and a need to improve systems and processes to ensure existing and new buildings are resilient in the face of a changing climate. There is also the need to raise the level of ambition across all eight activities, in particular the adoption of building codes and MEPS for appliances and equipment, along with low-energy building designs, improved cooling technologies and use of low-carbon materials.

Global effort in support of buildings and construction sector decarbonisation

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

The [GlobalABC](#) was launched at a COP21 as a voluntary partnership of national and local governments, intergovernmental organisations, businesses, associations, networks, and think tanks committed to a common vision: a zero-emission, efficient and resilient buildings and construction sector. The GlobalABC functions as a meta-platform that brings together initiatives and actors focusing on the buildings and construction sector.

Box 31 • The GlobalABC

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

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

The GlobalABC, through these activities, aims to mobilise all actors along the value chain, identifying priorities and goals towards decarbonising the built environment, while fostering transparency, inclusion and co-operation. The Global and Regional Roadmaps are key steps in this process.

As part of the 2018 Clean Energy Ministerial, six GlobalABC member countries (Argentina, France, Germany, Mexico, Morocco and Switzerland) signed the [Global Call for Low-Carbon, Energy-Efficient and Resilient Buildings](#) to develop national strategies for buildings and construction in line with the Paris Agreement goals. Furthermore, multiple businesses, cities and regions have signed up to the

[Net Zero Carbon Buildings Commitment](#), which challenges companies, cities, states and regions to reach net-zero operating emissions in their portfolios by 2030, and to advocate for all buildings to be net-zero in operation by 2050. And countries, the private sector and financial institutions have signed up to the [Zero Carbon Buildings for All Initiative](#) as part of the UN Secretary-General's Climate Summit in 2019.

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

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Resources

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

Key resources:

- [Global Roadmap Towards Low-GhG and Resilient Buildings](#), Global Alliance for Buildings and Construction, 2016
- [Recommendation for Classification of Measures and Policies Related to Local Conditions](#), Ecofys Germany GmbH, 2017
- [Science-based Targets for Buildings, A framework for carbon emissions management along the building and construction value chain](#), WBCSD, 2018
- [Capturing the Multiple Benefits of Energy Efficiency](#), IEA, 2014

Additional Resources:

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

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

- [Roadmap for Implementation of Energy Efficiency in Public Buildings of Kyrgyz Republic](#), World Bank, 2019
- [Super Low Energy Building Technology Roadmap](#), Singapore BCA, 2018
- [Nearly \(Net\) Zero Energy Building Roadmap](#), APEC, 2018
- [A Carbon Positive Roadmap for the Built Environment](#), Green Building Council Australia, 2018
- [Roadmap for Healthy Buildings – 1st step: Harmonisation of Health Criteria for Construction Products](#), German Environment Agency, 2018
- [Roadmap to Healthy Low-Carbon Lifestyles, Cities and Buildings](#), Science Council of Japan, 2018
- [A Roadmap for Retrofits in Canada: A Detailed Roadmap for Reducing Greenhouse Gas Emissions from Large Buildings](#), Canada Green Building Council, 2017
- [Zero Energy Building Pathway to 2035](#), National Grid, 2016
- [Policy Roadmap to 50% Energy Reduction in Chinese Buildings by 2050](#), LBNL, RMI and ERI, 2016

- [Roadmap to Resilient, Net-Zero Buildings in the Pacific Northwest, Pacific Northwest Economic Region, 2015](#)
- [Washington State Energy Code Roadmap](#), NBI, 2015
- [Buildings Modernisation Strategy: Roadmap 2050](#), Poland and BPIE, 2015
- [Roadmap to Zero Emissions](#), Architecture 2030, 2014
- [NASA Net Zero Energy Buildings Roadmap](#), NREL, 2014
- [A Guide to Developing Strategies for Building Energy Renovations](#), BPIE, 2013
- [Strategy Roadmap for Net Zero Energy Buildings in India](#), USAID, 2011
- [Roadmap to Green Government Buildings](#), USGBC, 2011
- [Measurement Science Roadmap for Net-Zero Energy Buildings](#), NIST, 2010
- [Roadmap for a Transformation of Energy Use in Buildings](#), WBCSD, 2009
- [Going the Distance: The Low-Carbon Buildings Roadmap](#), CBI, 2009
- [Roadmap For Positive-Energy and Low-Carbon Buildings and Building Clusters](#), ADEME
- [Better Buildings Through Energy Efficiency: A Roadmap for Europe](#), Eurima, 2006
- [High-Performance Commercial Buildings: A Technology Roadmap](#), US DOE, 2000
- [Model Regulation Guidelines: Energy Efficiency and Functional Performance Requirements based on International Standards](#), U4E, 2019

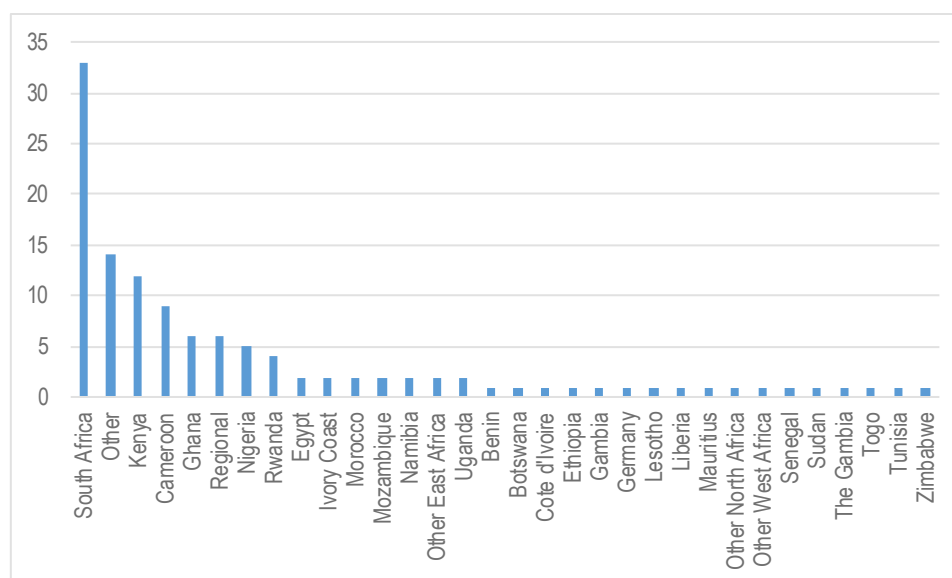
Annex: List of stakeholder engagement events and organisations consulted for the Africa Roadmap

This roadmap is the product of multiple workshops, webinars, surveying surveys and conversations with experts across Africa. The process involved deep in-depth consultation with over 100 individuals from various countries in Africa over the course of the development of this regional roadmap.

The in-person events that have taken place and specifically gathered Africa Roadmap inputs are listed below:

- **GlobalABC Regional Roundtable for Sub-Saharan Africa** in Nairobi, Kenya, May 2019
- **IEA Energy Efficiency Policy Training Week for Sub-Saharan Africa** – buildings stream, October 2019

Figure 37 • Participants in the Africa Roadmap process



Acronyms, abbreviations and units of measure

ABMT	appropriate building materials and technology
AFD	Agence Française de Développement
AMEE	Agence Marocaine pour l’Efficacité Energétique
AVN	Nubian Vault Association
BAT	best available technology
BEA	Building Efficiency Accelerator
BEEC	Building Energy Efficiency Code
BESS	battery-energy storage systems
BIM	building information modelling
BMS	building management systems
BMZ	German Federal Ministry for Economic Cooperation and Development
CEEC	Community Education and Empowerment Centre
CO ₂	carbon dioxide
COP	coefficient of performance
COP21	21st Conference of the Parties
CSP	concentrated solar power
DC	direct current
DiMSUR	Technical Centre for Disaster Risk Management, Sustainability and Urban Resilience
DIY	do it yourself
ECOWAS	Economic Community of West African States
EEPBP	Energy Efficiency in Public Buildings and Infrastructure Programme
EER	energy efficiency ratio
EMS	energy management systems
EPD	Environmental Product Declaration
ESCO	energy services company
G7	Group of Seven
GBC	Green Building Council
GDP	gross domestic product
GIS	geographic information system
GIZ	German Development Cooperation
GHG	greenhouse gas
GlobalABC	Global Alliance for Buildings and Construction

HRDC	Habitat Research Development Centre
HVAC	heating, ventilation and air conditioning
IDP	integrated development plans
IEA	International Energy Agency
IFC	International Finance Corporation
IGS	International Green Structures
K-CEP	Kigali Cooling Efficiency Program
LCA	life-cycle assessment
LED	light-emitting diode
LPG	liquefied petroleum gas
low-e	low-emissivity
MECS	Modern Energy Cooking Services
MEMDD	Ministry of Energy (Morocco)
MEPS	minimum energy performance standards
NAMA	nationally appropriate mitigation action
NDC	nationally determined contribution
NGO	non-governmental organisation
OTTV	overall thermal transfer value
O&M	operations and maintenance
PACE	property-assessed clean energy
PIE	progress, impact, effort
PPA	power purchase agreement
PPGIS	public participation geographic information system
PSEE	Private Sector Energy Efficiency
PV	photovoltaic
R&D	research and development
RACI	responsible, accountable, consulted, informed
RTS	Reference Technology Scenario
SDG	Sustainable Development Goal
SDS	Sustainable Development Scenario
SEER	seasonal energy efficiency ratio
SHGC	solar heat gain coefficient
SOLTRAIN	Southern African Solar Thermal Training and Demonstration Initiative
STEPS	Stated Policies Scenario
SWHS	solar water heating system

SWOT	strengths, weaknesses, opportunities and threats
TOD	transit-oriented design
UHI	urban heat island
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollar

Units of measure

GtCO ₂	gigatonne of carbon dioxide
GW	gigawatts
GWh	gigawatt-hours
km ²	square kilometres
lm/W	lumens per watt
m ²	square metre
MtCO ₂	million tonnes of carbon dioxide
MtCO ₂ /TWh	million tonnes of carbon dioxide per terawatt-hour
Mtoe	million tonnes of oil equivalent
MW	megawatts
toe	tonnes of oil equivalent
TWh	terawatt-hour
W/m ²	watts per square metre
W/W	watts per watt

